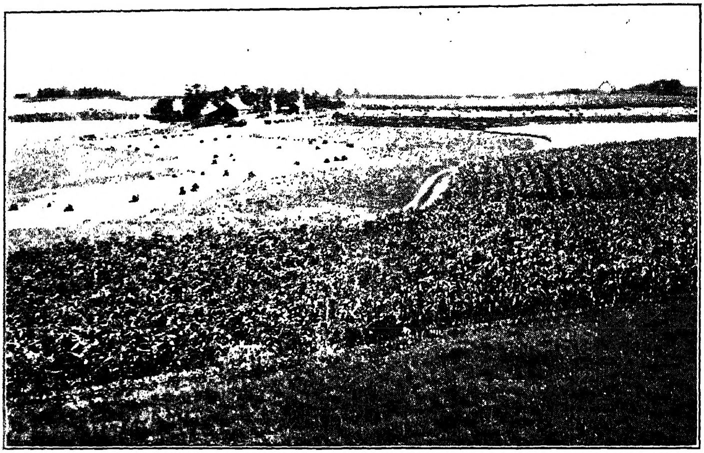

Frontispiece. THE AMERICAN FARM FAMILY'S PRIMARY OBJECTIVES ARE TO SUPPLY THE NATION'S NEEDS FOR FOOD, CLOTHING, AND MATERIALS FOR MANUFACTURE DURING PEACE OR WAR, PROVIDE A SATISFACTORY LIVING FOR THE FARM FAMILY, AND DEVELOP A PERMANENT AND EVER-IMPROVING AGRICULTURE. (*U.S.D.A.*)

FIELD CROPS and LAND USE

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This book is dedicated to the growing army of American farmers who plan and execute their programs of efficient crop and livestock production so as to improve the fertility of the soils in their charge, provide for the Nation's needs during times of peace and war, and assure the onward course of our Country toward ever-increasing prosperity and enhanced freedom.

FOREWORD

In these times when war demands the utmost of agriculture, it is gratifying to note the appearance of this book on field crops and land use. The authors have set forth the primary importance of agriculture in furnishing the diversified food and raw material needs of our Nation and of our Allies and have suggested methods of crop production that increase yields per acre and conserve and improve soil fertility. Our primary job now is production to win the war and make the Nation secure. When the war is won, the products of our farms will be needed to feed the starving millions of Europe and will play an important part in assuring a just and lasting peace and the continued development of our civilization.

CLAUDE R. WICKARD
Secretary of Agriculture

April 4, 1942

PREFACE

It is the purpose of this book dealing with crop production practices and land use methods to present the progress made to date in the great national program of efficient farming, agricultural adjustment, and conservation. Effort is made to present in detail the results of the work of the agricultural experiment stations of the land-grant colleges and of the United States Department of Agriculture in developing and improving crop varieties and in improving practices of crop and soil management.

Particular attention is given to the presentation of the new opportunities offered to farmers to improve methods of crop production and marketing and soil conservation by cooperating in the local programs of the State Extension Services and the many new action agencies authorized by Congress to improve agricultural opportunities and conserve our soil.

The importance of crop production to the nation's prosperity and in war times is emphasized, and chapters are presented dealing with the home farm food supply. The contributions and opinions of agricultural experimenters and thinkers and leaders are freely drawn upon. It is hoped that this book will be of service in advancing modern ideas and methods of efficient crop production and land use and the conservation of our farm resources of soil, water, and plant and animal life.

Through individual action on the farm and cooperation with all agencies that constitute the agricultural program of community, state, and nation, our present and future prosperity and strength can be best served.

THE EDITORS AND AUTHORS

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PART I

CHAPTER I

AGRICULTURE AND AMERICAN PROSPERITY AND STRENGTH

The physical and mental vigor of man depends largely upon food supplies. We think and act to a great degree in accordance with what we eat. Our health, activity, and well-being are also influenced by what we wear. Our supply of food, the fiber and wool for our clothes, and the leather for our shoes come from crops grown on the land or from livestock and poultry produced from these crops. No other nation has such a variety and abundance of food products and clothing materials. Measured in dollars, the annual farm production consumed by man and domestic animals and used in industry reached a total of over eleven billion dollars in 1941. The value of dairy, livestock and poultry products, and workstock produced by grazing and feeding field crops was $6,391,107,000 in 1941, and the total value of all field crops was $4,794,323,000.

The real value of our essential food and clothing supplies cannot be measured in dollars alone when it affects the livelihood and achievements of American farmers and workers, the mental capacity and ingenuity of our inventors and statesmen and our professional and business men, and the mental and physical stamina of our people.

Ample and balanced supplies of forage and grain, oil and protein feeds, are the foundation of our great livestock, dairy, and poultry industries. The essential minerals and vitamins of foods are dependent upon crop practices that make these elements available to man and to animals in the form of efficiently produced field crops. The cost of producing livestock products depends upon the careful planning of crop rotations and upon efficient cultural practices that will produce on the farm to the greatest possible extent the feed crops needed for balanced rations for livestock and poultry.

The conservation and increase of the mineral elements of the soil that are essential to plant growth are necessary for the continuance

on a profitable basis of our great livestock, dairy, poultry, and food- and fiber-crop production. Our large centers of population are dependent upon the continuance of ample supplies of milk, meats, poultry products, and truck crops at reasonable prices from producing areas. The crop-production practices that maintain and improve fertility on the New York Milk Shed, for instance, contribute directly to the permanent maintenance of the power, wealth, and prestige of the City of New York.

Phosphorus has been termed the key to successful farming. Under our present system far too much phosphorus goes to the sea and is lost to agriculture. Necessary crop-production practices are those that maintain or increase the essential minerals—phosphorus, calcium, magnesium, potassium, sulphur, boron, and the nitrogen supply. Pastures that are improved by mineral treatments and grazed at the right time and fertilized meadow crops that are cut when a maximum of digestible mineral nutrients and vitamins is contained in the hay or ensilage result in more efficient meat and milk production of higher quality, greater profits to the producer, and increased health and strength for the consumer.

AGRICULTURE, INDUSTRY, TRANSPORTATION, AND BUSINESS ARE INTERDEPENDENT

American industry draws heavily on crop products and by-products produced from them for basic raw materials. Cotton is manufactured into cotton cloth, mattresses, thread and twine, and other cotton products, such as rayon and explosives. Cotton seed is an important source of oil and oil feeds. Wheat is manufactured largely into flour and mill feeds, starch and gluten products, and vitamin extracts. Wheat is an important poultry and livestock feed. Corn is our most important livestock feed, but it is also the source of corn meal, corn starch, corn sugar, and many other products. The soybean is now important in the production of oil for paint and for human consumption. Soybean meal is a valuable livestock feed and is also used in making plastics that enter into automobile production and into the manufacturing of household articles. Flax furnishes fiber for linen, twine, and paper, and oil for paints and varnishes. Linseed meal is an important, concentrated livestock feed. Sizing starch is now manufactured from the sweet potato. The sugar beet is an important source of the American sugar supply. Corn, rye, and rice are used in the manufacture of alcohol.

TABLE 1

NATIONAL RESOURCES' PLANNING-BOARD ESTIMATES OF OUR LAND PRODUCTS

	Acres (Millions)	Percentage of Total	Value (Millions)	Percentage of Total
PRINCIPAL CROPS:				
Corn	97.7	27.0	$2093	25.9
Cotton	43.2	11.9	1463	18.1
All vegetables	5.8	1.6	1002	12.4
Hay	67.8	18.7	986	12.2
Wheat	62.0	17.0	840	10.4
All fruits and nuts	6.1	1.6	656	8.1
Oats	36.5	10.0	428	5.3
Tobacco	1.9	.5	267	3.3
Barley, sorghums, etc., and others	51.0	11.7	345	4.3
Total crops	372.0	100.0	$8080	100.0

	Number on Farms (Millions) *	Annual Production (Billions) †	Annual Value (Millions)*
LIVESTOCK:			
Meat animals:			
Cattle and calves (including milk cows	66.8	14.2 pounds meat †	$ 940
and heifers)	(25.1)	107.0 pounds milk	1826
Hogs	49.0	14.4 pounds meat	1103
Sheep and lambs	48.1	2.2 pounds meat	136
		0.37 pounds wool	
Chickens	412.6	0.65 (birds) meat	373
		3.11 dozen eggs	618
Turkeys	6.4	0.026 (birds) meat	69

	Capital Value * (Millions)
Work animals:	
Horses and colts	$1014
Mules and mule colts	548

* As of Jan. 1, 1939. † For 1938.

American industry is largely dependent on agricultural production for its permanent and future development. The preparation of crop and meat products has necessitated our colossal milling and meat-packing industries and food-manufacturing plants that produce feeds for human beings, livestock, and poultry. The cotton mills of New England and the Southern States represent large investments and employ great numbers of workers. The business of supplying agriculture with the products used in production, such as fertilizers, lime, seed, farm machinery, and fencing and building materials, has developed into great industries, employing hundreds of thousands of people and putting large amounts of capital to profitable use. The mail-order business, initiated primarily to supply farmers, has developed enormously, though the greater part of the business of providing farmers with needed production materials and the home and family equipment is performed by the local community merchants. Financing farming and closely related industries employs a great part of the capital of our banks, life insurance companies, trust companies, and the funds of the Federal Farm Credit Administration.

Crop and livestock products constitute the greatest part of the materials transported by train, truck, or water. In addition to the freight hauled from the farm, the tremendous business of manufacturing and transporting lime, fertilizer, farm machinery, and manufactured products for farm use must be maintained without interruption. The major cities of the Midwest and our leading seaport cities are located on their present sites owing to favorable water or rail facilities for the transportation of farm products.

It may be truly said that a prosperous agriculture is fundamental to the prosperity of labor, capital, commerce, and industry. An old Chinese proverb says: "Prosperity is like a tree, agriculture its roots, industry and commerce its branches and leaves. If the roots suffer, the leaves wither and the tree dies."

Efficient Crop Production Is Essential to Prosperity

Crop-production practices for achieving a more profitable agriculture and the conservation and improvement of the soil are fundamental, not only to crop and livestock production but also to the stability and future prosperity of our national business and commercial enterprises. Farm prosperity and business prosperity go hand in hand. Our national prosperity for peace or war depends basically on our food supply.

As stated by the Hon. Henry A. Wallace, when Secretary of Agriculture: "The road to opportunity and decent training is food. People as well as animals must be well fed if they are to be and do their best. Our future development in the finances, industries, and arts depends on a sound, permanent, and improving agriculture."

The vigor of our people now and later is proportionate to the abundance and diversity of our food products and, from the standpoint of our national vigor, to the extent to which our bountiful supply of food is made available in adequate amounts to all classes of our population.

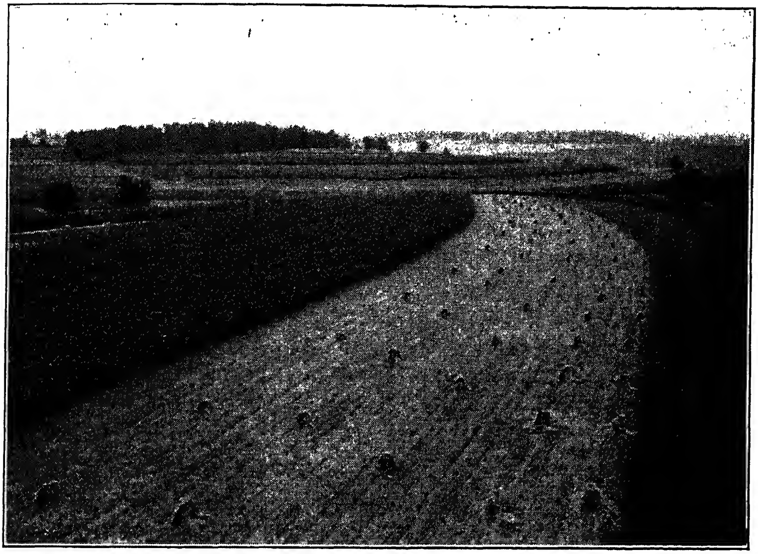


Fig. 1. The cropping system of this Iowa farm has been planned to reduce erosion by strip cropping with oats, corn, and alfalfa along contours. (*Soil Conservation Service, U.S.D.A.*)

Agricultural Exports

Agricultural exports have provided an important addition to the American farmer's income. Since the first World War and the program of strengthening domestic production that prevailed among European nations, the exports of wheat and meat from America have fallen rapidly. Cotton exports have also declined. Processed meats, flour and other milled products, processed foods, and tobacco more nearly maintained pre-war shipments until the blockade of European commerce in 1940.

Progress was made in offsetting the effects of barriers against American products through trade agreements with foreign nations. It had resulted primarily in the increased flow of exports of our products until the second World War nullified trade agreements with European nations.

The imports of agricultural products are determined largely by prices prevailing in the United States and the size of respective crop and animal supplies. In the main, imports have declined almost in proportion to exports.

The Soil Must Be Conserved

The importance of the proper use and maintenance of our soil resources is convincingly presented in "Soils and Men," the Yearbook of the United States Department of Agriculture for 1938.

Most people will agree that the broad underlying purpose guiding the use of soil resources should be "to maintain the highest possible standard of living for the people of the United States." This includes secure farm homes, adequate and stable incomes for farm people, and a continuous and abundant supply of farm products for all of the people. In other words, the soil problem is really a problem of the well-being of people.

Problems of Soil Misuse

An erosion reconnaissance survey of all the land in the United States, agricultural and nonagricultural—something over 1,900,000,000 acres—was made in 1934. A reconnaissance survey is not detailed or precise, but it is useful nevertheless. Among the facts brought out by this survey were these:

1. On 37 per cent—700,500,000 acres—of the total land area, mostly flat, gently undulating, or forested, erosion has been slight; less than one-fourth of the original surface soil has been lost.
2. On 41 per cent—775,600,000 acres—erosion has been moderate; from one-fourth to three-fourths of the original surface soil has been lost.
3. On 12 per cent—225,000,000 acres—erosion has been severe; more than three-fourths of the original surface soil has been lost.
4. Three per cent—57,200,000 acres—of the land area has by now been essentially destroyed for tillage.
5. About 7½ per cent—144,700,000 acres—consists of mesas, canyons, scablands, badlands, and rough mountain land. Overgrazing and other abuses on some of this land have caused moderate to severe erosion.

Remedies and Preventives

Good soil management, in the sense of maintaining fertility and productivity, depends upon a number of relatively simple practices. Broadly, five things are of first importance: (1) suitable tillage; (2) maintaining the

supply of organic matter, principally by the use of proper rotations and cover crops, including legumes; (3) correcting soil acidity in the humid regions; (4) providing an adequate supply of phosphorus; and (5) using mechanical measures to control erosion where rotation and cover cropping are not sufficient. This applies to general farming in most regions. In some

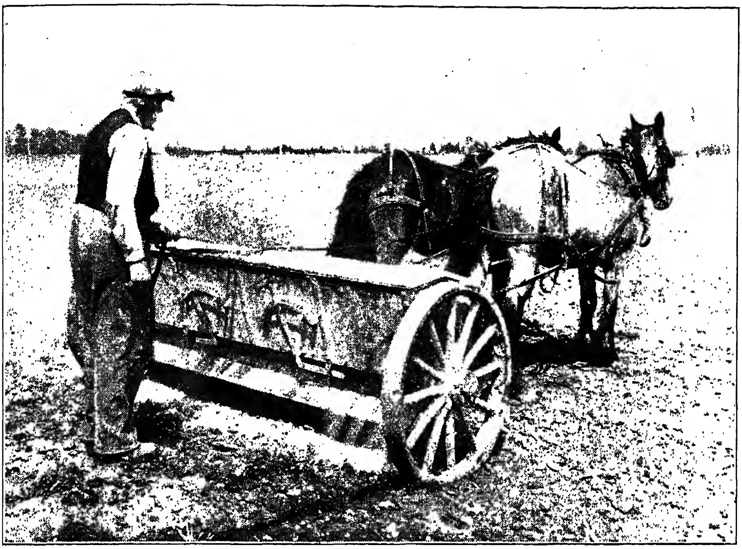


FIG. 2. This old man of the land, nearing the end of his days, applies practices, such as liming and phosphating the soil, that will benefit future as well as present generations. (*U.S.D.A.*)

areas and for special crops, there are special problems associated with water supply, drainage, nitrogen, potash, and certain minerals.

EFFICIENT CROP PRACTICES ARE OF PRIMARY IMPORTANCE

As a general rule, the farmer who produces the highest yields per acre reduces production costs and improves the quality of his products. The crop-adjustment program of the nation looks toward the reduction of crops in surplus through reductions in acreage agreed upon by cooperating farmers. The effect of acreage allotments that required fewer acres of corn, wheat, cotton, tobacco, potatoes, and other crops produced in surplus was to stimulate interest in efficient practices that would give maximum yields, such as better preparation of the land; growing cover and green-manuring crops; using lime, phosphate, and fertilizer; choosing the highest yielding variety; purchas-

ing the most effective machinery for cultivation; and improving storage methods, particularly for corn under the corn-loan program.

As an example of recent improvement in production practices the rapid increase of the use of hybrid corn is outstanding. It is estimated that more than 80 per cent of the corn acreage of the Corn Belt proper was planted to hybrid corn in 1940, resulting in increased yields over open-pollinated varieties of 10 per cent or more. The rapid increase in the growing of soybeans to replace oats in the Corn Belt, in the planting of lespedeza in the lower Corn Belt, and in the Cotton Belt, and in the planting of alfalfa and adapted clovers indicates marked improvement in crop rotation. In the eastern half of the United States the use of lime has been increased more than 300 per cent during the past five years, and the use of phosphate has doubled. Pasture-improvement practices, such as liming and phosphating and the planting of grass mixtures (including ladino, white clover, lespedeza, alfalfa, and clovers, as adapted), have come into general use. All these practices have been long recommended by our agricultural experiment stations and extension services and by experienced farmers and were made subject to direct financial award or grant-of-aid distribution of conservation materials under the Agricultural Adjustment Administration program, thus rapidly extending their application.

The development and wide-spread use during the past five years of the small type of rubber-tired tractors and of the small combine and other farm machinery on rubber tires has made a great contribution toward the efficient plowing, fitting, and cultivating of soils and the harvesting and marketing of crops.

The National Program for the Conservation of Soil Resources

The National Conservation Program is directed toward a solution of two problems: To use and improve the land and to secure an adequate income for farm families. The problem of maintaining national prosperity and farm prosperity without wasting soils, destroying forests, polluting and diverting water supplies, and destroying wildlife is an old problem that has not been wholly solved by any nation to date. Great dynasties have risen and prospered briefly during the past few thousand years of human history, only to fall into decay largely because of the depletion of the soil areas drawn upon for a comparatively few centuries to maintain the supply of food and clothing.

Our great agricultural thinkers of the past knew full well of the threat to our national prosperity that existed in the ruthless exploitation of our land and the general neglect of soil conservation practices that prevailed.

The late Director Charles E. Thorne, of the Ohio Experiment Station, said thirty years ago: "As for the farmer who undertakes to

FIG. 3. Farmers voting on wheat referendum. Under the Agricultural Conservation Program the growers decide in democratic fashion on acreage and marketing programs. The outbreak of the second World War found American farmers fully organized to produce the many farm products needed in the war production program. (*AAA, U.S.D.A.*)

take everything from the land without making any restitution, his liberty will eventually be taken from him and he will become the servant of wiser men, either on the farm or elsewhere."

Cyril G. Hopkins, the great agronomist of the Illinois Experiment Station, in his book "Soil Fertility and Permanent Agriculture," which he dedicated to THE ASSOCIATION OF AMERICAN AGRICULTURAL COLLEGES AND EXPERIMENT STATIONS—THE RIGHTFUL GUARDIANS OF AMERICAN SOILS, introduced his message to the farmers of America with the sentence: "Every landowner should adopt for his land a system that is permanent—a system under which the land becomes better rather than poorer."

TABLE 2 *

MAJOR LAND USES

	Millions of Acres	Percentage
LAND IN FARMS:		
Crop land harvested	359	18.9
Idle, failure, and waste	99	5.1
Plowable pasture	109	5.7
Nonplowable pasture	270	14.2
Woodland pasture	85	4.5
Woodland not pastured	65	3.4
Total	987	51.8
LAND NOT IN FARMS:		
Private forest (grazed)	143	7.5
Public forest (grazed)	106	5.6
Private forest (not grazed)	151	7.9
Public forest (not grazed)	57	3.0
Private grazing land	126	6.6
Public grazing land	203	10.7
Cities and towns	12	.7−
Parks, reservations, etc.	13	.7+
Roads, railroads	23	1.1
Desert, swamps, rocky, and dunes	83	4.4
Total	917	48.2
Total land	1904	100.0

* From Our National Resources, issued by the National Resources' Planning Board.

Though the United States Department of Agriculture Extension Service was not then in existence, Dr. Hopkins must have foreseen its development, for he realized that only through educating the farmers on the land would it be possible to develop a national program of effective soil conservation. As Hopkins stated, "The landowner must think for the land. . . . The agriculture of a State can not be managed from a central office."

Although the conservation problem is an old one, recent developments in the national conservation program have attacked the problem in many new ways, on many fronts, involving the cooperation of nearly 90 per cent of the people on the land.

Since 1932, powerful action agencies, reaching directly to millions of farmers, have been placed by congressional authority under the administration of the United States Department of Agriculture. These action agencies have included the Agricultural Adjustment Administration, the Soil Conservation Service, the Commodity Credit Corporation, the Farm Security Administration, the Surplus Marketing Administration, and the Rural Electrification Administration. These services, locally aided by county agents, have developed cooperative farmer leadership on the part of county planning committees, farmers' organizations, and federal and state conservation agencies working within the counties.

These programs have induced a great majority of farmers not only to "think for their land" but also to *do* something for it. It appeals to farmers everywhere who are taking advantage of the Agricultural Adjustment Administration practice awards to apply lime on acid soils, to use phosphorus, increase their acreage of legumes, and to improve pastures and carry out planned soil- and forest-conservation practices, and to adjust their cropping systems.

Another distinct feature of the present program is the emphasis being given to the conservation of human resources as one of the primary reasons for the need of conserving our natural resources. The home-food and feed-crop program for people on the land is an essential part of our conservation program.

Conservation is not a matter that concerns only the people of remote, future generations but is of importance to the people on the land today in increasing and protecting their income, adding to their material prosperity at the same time that soil, water, trees, and wildlife are conserved.

Before we look forward for a decade or so, let us look backward over the past ten years. In spite of all that has been done, the point has not yet been reached where the annual balance sheet for our fertility resources is "out of the red." During the past ten years great droughts have swept the country, accompanied by dust storms that clouded the skies of nearly half the nation. The greatest floods on record in America have occurred in the Mississippi and Ohio Valleys and in New England. In 1932, our farm income sank to its lowest level. Fortunately the low income of $4,250,000,000 of 1932 was raised quickly, through the cooperation of farmers in federal and state programs, to more than $11,000,000,000 in 1941.

During the past ten years we experienced our greatest losses from erosion by wind and water, but during this period came the realiza-

tion that it is necessary to adjust our farming practices to prevent these losses. This period has brought into being plans and agencies which if continued and improved for ten years hence may well place American agriculture on a basis not only of fertility maintenance but of improvement of soil fertility.

The Agricultural Extension Service has accepted the responsibility of finding and training the right leadership in all our communities to continue with the harmonious development of the many agencies, federal, state, and local, necessary to develop an adequate conservation program. Progress now being made in coordinating all conservation agencies assures us that we can reasonably expect that a decade hence the farm families of this nation will enjoy a more secure and bountiful prosperity; that they will be living in better homes, with better heating, lighting and water facilities; that they will be living in better communities with improved roads and schools; and that farmers on the land will be farming better soils, protected to a much greater degree from erosion by leguminous crops and improved pastures, soils with an increased content of lime and phosphorus and organic matter; that theirs will be farms that constitute valuable heritages and not liabilities for future generations.

A Thriving Agriculture Essential to Prosperity and to National Protection

Vigorous preparation for national defense and offense requires that American agriculture, business, and industry must be prosperous. Nearly 25 per cent of the people of the United States of America live on farms and receive about 20 per cent of the national income. This one-fourth of the people of America produces one-third of our children and is responsible for the education and upbringing of this one-third of our national increase of population.

If three-fourths of the nonagricultural public is given a higher income, increased farm prosperity is assured by the higher purchasing power of the consuming public. However, the remaining 25 per cent, the group of people on the land, consists of the most important purchasers of farm machinery, work shoes and clothing, leather, gas, oil, and other materials that are used in production; thus, if agriculture receives a higher income, those engaged in manufacture, transportation, and business are materially benefited. Increased incomes for farmers, for labor and business, are contributory one to another and are essential to national prosperity.

Our national income of $74,000,000,000 may increase to $90,000,000,000 or $100,000,000,000 annually, chiefly as a result of war expenditures. The outlook for farmers who produce for domestic consumption and for lend-lease purchases for our allies appears good for the next few years. Dairymen, livestock and poultry producers, truck crop growers, fruit growers, and producers of agricultural specialties, such as oil crops, seed, and drug plants, should experience improved conditions resulting from increased demands.

The outlook for farmers whose products are for the export market, such as corn, cotton, wheat, tobacco, is not so good. Our export market has been cut off through blockade and the intensely nationalistic programs of European nations. The impoverishment by war of nations that were formerly our important customers can be expected to affect our export market adversely for many years to come. The growers of cotton, wheat, and corn must adjust their production programs accordingly.

Better Distribution of Domestic Food Supplies

In spite of the fact that this nation frequently produces embarrassing price-depressing surpluses of corn, wheat, cotton and of milk, meats and vegetables, and fruits, the fact remains that owing to inadequate food distribution, due to the low income of nearly 25 per cent of our people, the greater part of our poorer people do not get enough of the right foods and suffer from undernourishment. This problem has been attacked through relief agencies, the food stamp plan, W.P.A., and other means. It is recognized that it can only be wholly met by finding jobs in satisfactory ways for all who can work. It is also recognized that many families on the land, through low income or lack of information, do not eat properly balanced diets.

An important phase of the National Defense Program is a program of better living both for families in towns and cities and on the land in order to strengthen the vitality of our people. Increased consumption of foods high in vitamins, fruits, vegetables, meats, milk and poultry products, and of sea foods is being widely encouraged. Great progress has been made in organizing our production. No difficulty is anticipated in meeting the needs of our people for all essential food supplies with rationing of sugar and certain other commodities as needed.

The home production of food and feed crops on the farm is receiving wide-spread and organized attention. The growing and pre-

serving of garden products and meats and the wider use on the farm of home-produced dairy and poultry products are major objectives of the Agricultural Extension Service, and are being encouraged directly by garden programs and increased plantings of grass, legumes, and feed crops to be used on the farm under the Agricultural Adjustment Administration program and by farm security and farm credit requirements. The war program will influence American agriculture not only through an increased demand for certain food products but through the establishment of new industrial centers in agricultural areas of excess farm labor.

THE FARMERS' PLACE IN NATIONAL DEFENSE

In answer to the question, "What immediate action can farmers take to prepare agriculture for its fundamental role in our national emergency?" the Hon. Chester C. Davis,[1] in charge of the Agricultural Division of the National Defense Advisory Commission, stated the following:

> Farmers can take "efficient production" as a watchword. Efficient production means employing farming practices that will get the highest yield from the fewest acres. It means lowering the production costs and at the same time improving quality and increasing value.
>
> It means following a farm program that will maintain the price level by guarding against too great an acreage expansion in crops of which there is a price-depressing world surplus, and diversifying to bring new cash income from produce which can be sold and used at home.
>
> It means exercising farseeing care in conserving the fertility of the soil, by practices which not only prevent waste of fertility but help to restore it.
>
> Production of farm income, storage of reserve supplies, and conservation of the fertility of the soil are essential to national defense. Accomplishment of them demands action on the part of farmers themselves.
>
> It is fortunate for agriculture that it has developed on the farm the leadership, ingenuity, and farm programs which have helped it meet economic emergencies in the past. It will be necessary to meet the new problems brought about by the war abroad with greater leadership, foresight, and courage.
>
> In this, farmers have the cooperation of the State and Federal agencies and also industry serving the farmers' needs.

[1] *The Fertilizer Review*, Vol. XV, No. 4, October–November–December, 1940.

THE AGRICULTURAL WAR PROGRAM FOR 1942—THE LARGEST PRODUCTION OF ALL TIMES

At the close of the first season of agricultural defense, Secretary of Agriculture Wickard announced that "food will win the war and make the peace." Working in cooperation with farm organizations, state

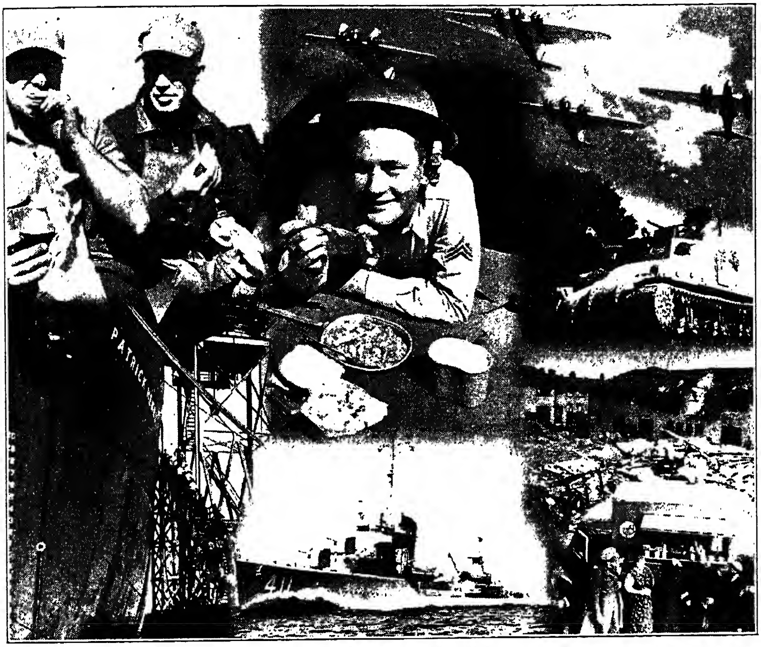


FIG. 4. American farmers, cooperating in a vast agricultural war program, insure, for domestic and war use and for lend-lease purchases for Great Britain, the production of ample supplies of the meat, bread, milk, eggs, fats, vegetables, and fruit needed for energy-producing and health-protecting rations. (*Van Rensselaer Sill, AAA, U.S.D.A.*)

land-use committees, and extension services, the Farm Credit Administration, the Farm Security Administration, and other agencies, specialists of the Department of Agriculture prepared estimates of agricultural products needed to improve the health of the nation, provide England and other democracies with needed food, and build up food "stockpiles" that could be drawn upon for war purposes or to feed war-wearied peoples when peace returns.

The Secretary of Agriculture made the call for defense production at four regional meetings. The defense program encouraged the pro-

duction of increased supplies of milk and dairy products, meat, poultry and eggs, and greatly increased production of oil crops, such as soybeans, peanuts, and flaxseed. Tomatoes, peas, and beans for canning and other truck crops and navy beans were needed in greatly increased quantities. A goal of 5,760,000 farm gardens was set for 1942, an increase of more than 1,250,000 above the number of gardens in 1929.

The job of reaching every farm family in America in the farm-to-farm canvass was undertaken by the Agricultural Adjustment Administration, aided by the agricultural extension services of the states. Every farm family was asked to develop a farm plan that indicated the production program of its farm for agricultural defense. These defense farm plans presented the program of crops to be planted, of livestock and poultry to be raised, and of the support for farm living to be obtained from the garden crops and livestock and poultry products consumed on the farm. No program of education and farmer cooperation had ever been undertaken before in this or any other country on so vast a scale.

"After Pearl Harbor"

After the treacherous attack by Japan at Pearl Harbor, Hawaii, on December 7, 1941, the farm production of the United States was adjusted on a war basis, and Secretary of Agriculture Wickard on January 16, 1942, called for the largest American farm production in history, stating that adequate farm production is vital to the nation's existence and that the task of achieving it would command the energy and devotion of every farm family.

The following table presents the war goals for 1942, the defense goals announced in September, 1941, and the acreage, production, and livestock slaughter for 1941. There is no precedent in history for this war agricultural program backed by 6,000,000 American farmers, cooperating in a program of war production of essential food, clothing, oil, and raw materials deemed necessary for the nation's safety and ultimate victory.

In addition to the goals for the commodities listed below, the expected acreage of other crops or production of other classes of livestock was also announced. These are the acreages or production which it is expected will be planted or produced in 1942, in view of the current supply and price outlook. In general, it is believed that adequate acreages or supplies of these crops and classes of livestock

TABLE 3

THE AGRICULTURAL WAR PROGRAM OF THE UNITED STATES

ANNOUNCED BY THE SECRETARY OF AGRICULTURE, CLAUDE R. WICKARD, JANUARY 16, 1942

Commodity	Unit	1941	September Goal	Revised Goal	% 1941
		Thousands of units			
Milk	pounds	116,500,000	125,000,000	125,000,000	107
Eggs	dozen	3,728,000	4,000,000	4,200,000	113
Chickens	Number marketed	585,000	644,000	644,000	110
	Farm production only, does not include non-farm production or commercial broiler output. The September goal has been restated in line with the revised estimate of numbers for 1941.				
Hogs	number	72,500	79,300	(slaughter) 83,000	114
Corn	acres	87,164	87.5 to 90,000	92.5 to 95,000	108
Cotton	acres	23,250	22 to 24,000	25,000	108
	Within this acreage, a shift toward the production of longer staples will be encouraged in the areas where such cotton can be produced.				
Wheat	acres	62,400	50 to 55,000	55,000	88
Tobacco:					
Flue-cured	acres	732	762	843	115
Burley	acres	357	358	383	107
Other domestic	acres	261	247	272	104
Rice	acres	1,245	1,200	1,320	106
Sugar cane	acres	265	*No acreage restrictions in 1942.*		
Sugar beets	acres	775	*No acreage restrictions in 1942.*		
Dry beans	acres	2,304	*Same as 1941.*	2,600	113
	Goal for dry beans is increased acreage for white, pink, and pinto beans; other varieties about the same acreage as in 1941.				
Dry field peas	acres	384		665	173
Canning peas	cases	28,700		38,000	132
Canning tomatoes	cases	34,000		40,000	118
Farm gardens	number	4,431	about 5,760	about 5,760	130
Turpentine	barrels	285	400	450	158
Rosin	barrels	950	1,333	1,500	158
Cover crop seed	acres	265	415	415	157
Soybeans	acres	5,855	7,000	9,000	154
Flaxseed	acres	3,367	*Same as 1941.*	4,500	133
Peanuts	acres	1,964	3,500	5,000	255
	Goal for peanuts is about 1,600,000 acres for nuts, or same as 1941, and 3,400,000 acres for oil.				

will be obtained without any special encouragement or additional price support.

The following table compares the expected 1942 war acreages or production with the forecasts of September, 1941, and the accompanying data for 1941.

Commodity	Unit	1941	September Estimate	January Estimate	% 1941
		Thousands of units			
Cattle and calves	number	25,905	28,000	(slaughter) 28,000	108
	The marketing of cattle and calves, equal to the estimated production, is recommended in order to stabilize cattle numbers and increase the available supply of meat.				
Sheep and lambs	number	22,630	22,900	(slaughter) 22,900	101
Wool	number shorn	48,900	51,200	51,200	105
Turkeys	number marketed	32,500		35,750	110
Oats	acres	39,363	40,000	40,000	102
Barley	acres	15,080	about 14,375	16,000	106
Rye	acres	3,500	*Same as 1941.*	3,550	101
Grain sorghum	acres	9,397	9,375	10,000	106
All hay	acres	71,893	74 to 75,000	72,000	100
Potatoes	acres	2,793	about 3,060	about 3,060	110
Sweet potatoes	acres	843	about 850	about 850	101
Fresh vegetables:					
Commercial truck	acres	1,680	about 1,785	about 1,840	110
Market gardens	acres	1,065	about 1,075	about 1,075	101
Canning vegetables	*Other than peas and tomatoes, about the same as 1941.*				
Fruit	*Total production about the same as 1941. Fruit production cannot be easily increased, and emphasis should be on prevention of waste and better distribution of utilization as among fresh, dried, and canned.*				
Hay crop seed	acres	3,923		4,919	125
Lumber	board feet	32,500,000		33,600,000	103
Pulp wood	cords	14,300		14,300	100

Price-support levels to the extent of 85 per cent of parity were announced for hogs, poultry, eggs, milk, dry peas and beans, peanuts, soybeans, and flaxseed.

CHAPTER II

CLASSIFYING FIELD CROPS

The agricultural crops of America are classified in accordance with their botanical relationships; the use made of the crops for food, fiber, pasturage, medicinal or other purposes; and, during the recent years of awakened interest in soil conservation, crops have been classed as "soil conserving" or "soil depleting," in accordance with their general effect in preventing erosion or leaching, maintaining fertility, and increasing organic matter in the soil, or in depleting fertility and permitting or encouraging erosion and leaching.

The term "field crops" refers to plants grown in cultivated fields or in pastures and meadows on a farm scale, or under an extensive system of agriculture.

The science of agronomy deals with the culture of field crops, including the preparation of land, planting, cultivating, harvesting, and preparing field, pasture, and hay crops for market.

Horticultural crops are those grown in the garden, orchard, or vineyard or on an extensive scale for truck, canning, drying, and quick-freeze purposes. They consist in the main of the fruit and vegetable crops harvested and used for human food in fresh condition or canned, dried, or frozen.

LEADING BOTANICAL RELATIONSHIPS OF FIELD CROPS

The great majority of field crops belong to two botanical families—the Gramineae or grass family, characterized by our grain crops and pasture, lawn, and hay grasses, and the Leguminosae or legume family, of which peas, beans, and the clovers are leading examples. The nightshade or Solanaceae family is represented among cultivated plants by tobacco and the potato. Cotton belongs to the mallow family, Malvaceae; rape and cabbage to the Cruciferae; sugar and stock beets to the Beta family; etc. (The botanical relationships of individual crops is dealt with more specifically in Part II.)

The grass family includes the majority of our hay, pasture and native range plants, and our leading cereals, corn, wheat, rye, oats and barley.

The grasses are characterized by jointed, generally hollow stems, sheathed with parallel-veined leaves alternating at the joints or nodes. Most grasses are open- or wind-pollinated (for example, rye, timothy, and bluegrass), but some are close-pollinated, such as oats, wheat, and barley. The grasses include annuals that complete their growth period in one season and perennials that continue growth for two or more years.

The pasture and hay grasses form a dense top cover and develop a network of fine roots in the surface soil, making them of particular value as a class in protecting the soil from losses due to erosion and leaching and of value in adding organic matter to the soil.

The legume family is characterized by papilionaceous or butterfly-like blossoms that develop into seed-bearing pods, as illustrated by the bean and pea plants. The roots of legumes differ from the roots of other crop plants in that they bear nodules, resulting from the activity of *Bacterium radicicola* in properly inoculated soils. These nodules contain numerous bacteria which assimilate atmospheric nitrogen. The distinctive value of legumes in increasing nitrogen in the soil under proper management and in producing high protein feeds is due to symbiotic or partnership relations with the nitrogen-gathering bacterium.

The family Solanaceae includes the tomato, potato, and tobacco plants. These plants have succulent stems, broad leaves, and pulpy, seed-bearing fruits. The seed-bearing fruits rarely develop on plants of our modern potato varieties, which are propagated from the tuber. Seed from potato seedballs is utilized by plant breeders in search of new varieties. The seed of tobacco is the smallest seed used in our agriculture, 1 tablespoonful being sufficient to furnish plants for 6 or 8 acres.

The family Cruciferae includes the cabbage, kale, kohlrabi, cauliflower, rape, and Brussels sprouts. This family is characterized by its succulent leaves, stems, and roots.

SOIL-DEPLETING AND SOIL-CONSERVING CROPS

The work of the Soil Conservation Service and of the Agricultural Adjustment Administration led to the establishment of two major crop classes: *soil-depleting crops* and *soil-conserving crops*.

Soil-depleting crops include all cultivated row crops, small-grain crops, fiber crops, and legumes and grasses harvested for hay, grain, or seed purposes. These crops as a class draw heavily upon the ele-

ments of fertility in the soil. Losses by erosion and leaching are greater from land in cultivated crops than from land covered by close-growing crops that are not intertilled.

Soil-conserving crops are erosion-preventing crops that provide dense cover to the surface of the land, prevent the rapid run-off of rainfall, and bind the soil against erosion. Soil-conserving crops include also cover crops, green-manure or plow-under crops grown to be left on the land or turned under to increase the content of organic matter and nitrogen in the soil.

FIG. 5. Crotalaria at the Gulf substation of the Alabama Experiment Station. This plant is a valuable summer-growing soil-building legume in the Gulf States.

The Federal Agricultural Adjustment program during the three years of 1933 to 1935 encouraged the use of the contracted acreage retired from the surplus production of basic commodity crops, such as corn, wheat, cotton, and tobacco, for the planting of new seedings of grasses and legumes and for the planting of cover crops and green-manuring crops. Under the Soil Conservation program that has been in effect since 1936, definite payments of awards are made, or conservation materials, such as lime, phosphate, and seed of winter cover crops, are granted to cooperators who carry out the soil-conserving features of the program. Since liming and fertilizing, particularly with phosphate fertilizers, are needed to establish successfully new seedings of legumes and grasses and to improve depleted pastures and meadows, these practices are also included among the soil-conserving practices subject to AAA payments. It is estimated that more than 50,000,000 acres were shifted from soil-depleting crops to soil-conserving crops or included in planned terracing and strip cropping or wood-lot and windbreak plantings during the first eight years of the

AAA program. The use of lime for agricultural purposes increased from less than 2,000,000 tons to over 9,000,000 tons under the program.

The Agricultural Conservation program for 1942 includes the following classification of crops as a guide in determining the basis of AAA payments on individual farms for employing soil-conserving practices under the program. It is estimated that over 6,000,000 of the approximate total of 7,000,000 American farmers are cooperating in the conservation program.

The following are excerpts from the 1942 Agricultural Conservation Program Bulletin of the Agricultural Adjustment Administration, United States Department of Agriculture.

Minimum Soil-Conserving and Soil-Building Requirements

In each county one of the following four provisions shall be applicable as recommended by the State committee and approved by the Agricultural Adjustment Administration, except that the second and third paragraphs shall not be applicable in any county in which total farm allotments are determined:

Minimum Conserving Acreage

The net payments for any farm in connection with special crop and total farm allotments shall be subject to a deduction of 4 per cent of the maximum amount computed in connection with such allotments for each 1 per cent of the cropland on the farm by which the acreage of cropland on the farm devoted exclusively to one or more of the following uses, as recommended by the State committee and approved by the Agricultural Adjustment Administration, throughout the 1942 crop year is less than 25 per cent of the cropland on the farm:

(i) Perennial grasses or legumes, including new seedings, if seeded alone or with a nurse crop pastured or clipped green and left on the land.

(ii) Biennial legumes, lespedeza, or annual sweet clover, including new seedings, if seeded alone or with a nurse crop pastured or clipped green and left on the land.

(iii) Sudan, millet, or annual ryegrass, for pasture.

(iv) Seeded cover crops of which a good stand and good growth is left on the land.

(v) Summer fallow protected by methods recommended by the State committee and approved by the Agricultural Adjustment Administration.

(vi) Fallow-rice land, or rice land on which noxious plants are controlled by mowing.

(vii) Forest trees planted on cropland since 1935.

(viii) Austrian winter peas or vetch grown for seed.

(ix) Irrigated land qualifying under practice 57.

(x) Idle cropland on which approved terraces are constructed during the 1942 crop year.

Minimum Acreage of Erosion-Resisting Crops

The net payments for any farm in connection with special crop allotments shall be subject to a deduction of 4 per cent of the maximum amount computed in connection with such allotments for each 1 per cent of the cropland on the farm by which the acreage of erosion-resisting crops and land uses on the farm is less than 25 per cent of the cropland on the farm. Erosion-resisting crops and land uses for any county shall be determined by

FIG. 6. Lespedeza has become a leading pasture, hay, and soil-conserving crop in the East Central Region, southern Corn Belt, and northern Cotton Belt. (*U.S.D.A.*)

the State committee, with the approval of the Agricultural Adjustment Administration, and may include only cropland which is devoted in the program year to one or more of the following crops or uses:

Biennial or perennial legumes
Perennial grasses
Lespedeza
Crotalaria
Ryegrass
Green-manure crops
Fall-seeded small grains, other than wheat, not harvested for grain
Velvet beans
Forest trees
Protected summer fallow
Cowpeas
Thick-seeded sudan grass
Natal grass
Winter legumes
Soybeans
Sweet clover
Fallow-rice land, or rice land on which noxious plants are controlled by mowing
Land on which approved terraces are constructed and no inter-tilled row crop is grown
Peanuts hogged off

Land devoted to one or more of the above crops or land uses shall qualify toward meeting this requirement regardless of any other use of such land except when interplanted with row crops

Farm Conservation Plan

In counties, groups of counties, or States, upon recommendation of the State committee and the approval of the Agricultural Adjustment Administration, the net payment that would otherwise be made with respect to special crop allotments for any farm in the county, group of counties, or State, as the case may be, shall be reduced by 1 per cent for each 2 per cent by which the producers on the farm fail to carry out during the 1942 program year that part approved for that year of a farm conservation plan approved for the farm as one which, over a period of years as recommended by the State committee and approved by the Agricultural Adjustment Administration, will conserve the soil and increase its productivity. Such a plan shall provide for the carrying-out on the various parts of the farm of the soil-building practices needed for the proper balance between the various kinds of crops grown, for the elimination of erosion hazards, for the restoration of the necessary humus to the soil, and other good land uses. The amount of the deductions made under this provision, as estimated by the Agricultural Adjustment Administration, shall be available in the State or county where deducted for administrative expenses.

CLASSIFYING CROPS IN ACCORDANCE WITH USE

Field crops are classified in accordance with the purposes for which they are used. The *pasture crops* include herbaceous plants used for pasturing livestock and poultry. The grasses, such as bluegrass, redtop, and orchard grass, and the legumes, such as the clovers, alfalfa, sweet clover, and lespedeza, planted alone or in mixtures, are our leading pasture plants. Sudan grass, soybeans, and cowpeas, velvet beans, and kudzu are also used for pasture purposes.

A *pasture* is a field, planted with herbaceous plants, upon which animals graze. *Permanent pastures* are fields, planted to perennial grasses and legumes or permitted to develop native growth, which are used for a number of years for pasture purposes.

Hay or *meadow crops* are grown primarily for the production of hay from the properly cured stems and leaves. Most hay crops are important pasture crops. Timothy, redtop, orchard grass, brome grass, and western wheat grass are some of the more important hay grasses. Alfalfa, red clover, alsike clover, and lespedeza are among the most important legumes harvested for hay. Annual crops, such as small grains, Sudan grass, millet, soybeans, and cowpeas, are frequently cured for hay purposes.

The *cereals* are crops, chiefly grasses grown primarily for the use of their edible seed. Wheat, oats, barley, rye, corn, and grain sorghums are leading cereals of the grass family. In common usage, flaxseed used for oil and feed, buckwheat, and grain-producing millets are included among the cereals.

FIG. 7. Sudan grass and grain sorghums are great drought resisters. (*U.S.D.A.*)

Fiber plants include crops grown for fiber purposes, used in making textiles, ropes, twines and threads, mattresses and used as a source of cellulose for explosives and rayon. Cotton, flax, hemp, and sisal are leading fiber crops. *Sugar crops* are grown for the production of sugar. Sugar cane and sugar beets are the leading sugar crops, though large quantities of corn sugar are secured from the corn crop and sorghum syrup from sweet sorghums. Our leading *oil crops* are the soybean, the peanut, and flax. Corn and cotton seed are also important sources of oil.

The term *root crops* is applied to plants grown for their underground parts, whether true roots or tubers. Of the true roots, the sugar beet, turnip, rutabaga, and stock beet, carrot, and horseradish

are representative. The tubers generally classed as root crops include the potato, sweet potato, and artichoke.

Medicinal Plants and Stimulants. Peppermint and spearmint, ginseng, henbane, and belladonna represent plants grown for medicinal use. Tobacco, tea, coffee, yerba maté, and cocoa represent the leading crops used as stimulants.

Rubber plants are the source of natural rubber. The hevea tree (*Hevea brasiliensis*), a native of South America, is tapped for its rubber-producing latex in a wild state in Brazil, Ecuador, and other South American countries. The hevea tree is also grown in plantations in South America and much more extensively in Sumatra and the Netherlands Indies. The disruption of commerce after the spread of the second World War to the Pacific and the Netherlands Indies created great interest in the increase of other rubber-bearing plants such as guayule and rabbit brush, native desert plants of Mexico and our Southwest. The Castilla tree of Mexico and selected strains of goldenrod and the Russian dandelion were looked to as additional sources of rubber for use in the period of scarcity, pending large-scale production of synthetic rubber.

The following definitions are important from the standpoint of crop utility.

1. *Grass*, in a general sense, is a word applied to all plants used for hay or pasture. More properly the term is applied to members of the grass family generally used for pasture, hay, or soil coverage.

2. *Forage crops* include those plants grown as pasture, hay, fodder, or silage crops and used as roughage feed for livestock. Small grains or soybeans and other crops grown for hay, pasture, or silage, and root crops used for livestock feeding, are included under the term forage crops.

3. *Soiling crops* are crops such as corn, sorghum, sudan grass, rye, wheat, soybeans, and cowpeas that are cut when in a green state and fed to livestock.

4. *Silage crops* are grown for the purpose of cutting at the right stage of growth for preservation in the silo in order to furnish succulent feed throughout the winter. Corn and sorghum are the leading silage crops, but during recent years grasses and legumes in general are being used successfully in the silo.

5. *Green-manure crops* are grown for the purpose of plowing under, in order to increase the organic matter in the soil. Sweet clover, rye, rye and vetch, winter peas, crotalaria, lespedeza, soybeans, and cowpeas are leading green-manure crops.

6. *Cover crops* are grown for the purpose of protecting the soil from erosion losses and preventing leaching. Winter wheat and winter rye, hairy vetch, winter peas, crimson clover, and ryegrass are among the most important winter cover crops. Soybeans, cowpeas, lespedeza, crotalaria, and sudan grass are leading summer cover and green-manuring crops.

7. *Emergency crops* are quick-growing crops, used primarily to replace crops that have failed owing to adverse seasonal conditions, insect or disease injury. Buckwheat, sudan grass, and soybeans, all late-planted crops, can be used for this purpose. When extensive drought injures pastures and meadows, the planting of soybeans, sudan grass, and sorghum is widely resorted to, in order to provide needed pasture and hay.

8. *Supplementary crops* are grown with other crops to increase yields and feed value. Soybeans and cowpeas are frequently planted with corn to increase protein content. Rape and turnips are planted with corn with the last cultivation or on land adjoining corn fields to provide supplementary pasturage. The terms *nurse crop* or *companion crop* are applied to small-grain crops that are grown on the land at the same time that seedings of grasses, clover, alfalfa, or lespedeza are made.

9. *Straw* is the term applied to the stems and leaves of a crop from which the seed has been threshed. Wheat, oats, barley, and rye are our leading straw-producing crops. In a broad way the term straw is applied to the roughage remaining after the grain or seed crop is threshed from small-grain crops and millet, flax, alfalfa, clover, lespedeza, and sweet clover.

10. *Roughage* is a term applied to hay, fodder, stover, pasturage, silage, and roots used for animal-feeding purposes.

11. *Fodder* specifically means feed, but in this country the term is applied to corn or sorghum cut and cured before plants are fully matured.

12. *Stover* is the corn stalk and leaves from which the ear has been husked.

13. *Hay* is the term applied to the dried leaves and stems of grasses and legumes. It is generally cured in the field, but recently the artificial drying of hay in special hay driers that use heated air has increased in use. Among the chief hay crops are timothy, redtop, bromegrass, marsh hay, and alfalfa, clover, and lespedeza. The *cereal crops,* oats, wheat, barley, and rye, are frequently cut before full maturity for hay purposes. Soybeans, cowpeas, field peas, and vetch are frequently cut at the right stage of maturity for hay.

Brown hay results when grasses or legumes are stacked in a compact mass immediately after cutting and while retaining a high moisture content which encourages fermentation and heating. Brown hay is made in regions where frequent rainfall does not permit proper drying.

14. *Aftermath* and *rowen* are terms applied to the growth resulting after a hay crop of grasses or legumes has been harvested.

15. The term *catch crops* is applied to short-season crops, or crops grown between crops in rotation, or crops used to supplant crops that have failed. Buckwheat, rape, sudan grass, millet, soybeans, sorghum, fodder corn are frequently used as catch crops. During times of flood, drought, untimely frosts, or other causes of crop disaster, the catch crops are of great importance in providing feed and income.

CHAPTER III

CROP MANAGEMENT TO CONSERVE AGRICULTURAL RESOURCES

Pioneer farmers faced the job of clearing and burning primeval forests, or of breaking and taming tough prairie sods that had held the land for centuries, of draining wet lands and of bringing irrigation water to dry land. They and their families experienced suffering and privation, and frequently faced the danger of losing life itself in order to wrest a home from the wild country. They were the first line of intrepid Americans who prepared the way for the expansion and occupation of this country, and were quickly followed by others who mastered the art of cheap and efficient crop and livestock production and developed prosperous communities.

Little thought was given to returning the fertility removed from the land, or protecting the soil from erosion, by these several generations of farmers who contributed largely to the growth and development of our great and prosperous nation. The accumulation of the available fertility and humus of centuries was drawn upon prodigally during our period of growth and expansion. The wealth from the soil built prosperous farm homes, rich towns and cities, thriving industries, railroads, and the shipping lines of rivers, lakes, and seas.

The building of America, by our pioneers and those who followed in the ever-westward tide of settlement, was at the expense of the soil itself. The restitution of fertility and the enriching of our soil are matters of comparatively recent concern. The conservation and improvement of our soil is of importance not only to people on the land but also to the people of the nation as a whole, and the great job of protecting our remaining vast areas of soil, as yet not seriously impaired for profitable production, should be shared by all the people. A new policy of soil management must be encouraged by every possible means if our great heritage is to be maintained to serve as a foundation for the strength and prosperity of coming generations.

The farmer of today faces a new kind of pioneering, not so dangerous or rigorous as during the days of his forefathers, but in many ways as challenging to his courage and intellect. Today's farmer must not only produce crops and livestock products efficiently, but he

must return the elements of fertility removed, and protect his soil from erosion. In many cases he must repair land that has been seriously depleted by extractive cropping and erosion. In this worth-

FIG. 8. This "dust bowl" farm was abandoned when dust deposits covered fields and roads and encroached on buildings in the drought years of 1934 and 1935.

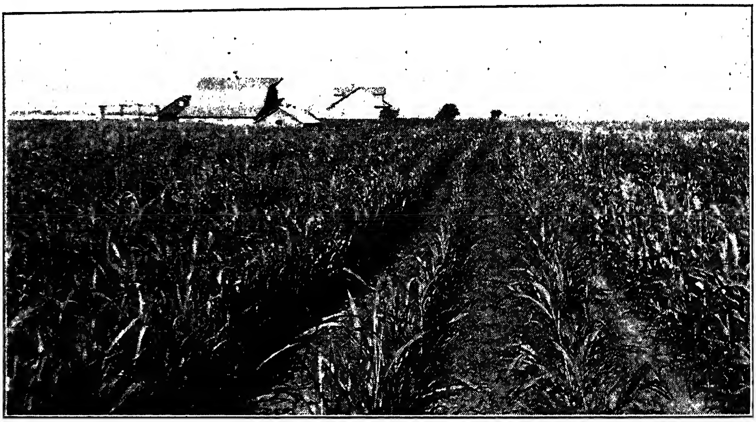


FIG. 9. Cover crops of sorghum and millet, excellent drought resisters, planted in 1937, hold down the ground and provide the first steps toward recovery.

while job modern science, farm cooperatives, and the awakened interest of our state and federal governments offer aid. While our soils have undergone great impairment, public interest has awakened to the importance of saving and improving the soil in order that our country may continue to move forward on its course of ever-increasing prosperity and power and democratic liberty and opportunity.

THREE PERIODS OF AMERICAN FARMING[1]

1841—The Early American Farm of the Expansion Period

The early American Farm was not much more than a clearing in the woods. The land was fertile and the farmer planted, cultivated, and harvested good crops with crude implements. His was a problem of sustenance and expansion in a new world. Handicapped by poor communication and lack of agricultural skill, he spent his life wastefully wresting a livelihood from nature. He would have been amazed to know he was destroying the soil because of the way he farmed the land.

1891—Farming in the Prosperous and Complacent Nineties

Fifty years later the farmer had cleared more land and drained his swamps by ditching. Buildings and roads were improved. Railroads and better vehicles brought farm and market closer together. Farm machinery produced larger and more abundant crops. Good crops and cash income diverted the farmer's attention from his gullied pastures, eroded fields, and silt-laden streams. Little did he realize his chief asset was slowly wasting away.

1941—Farming Today—Conservation and Security

The modern farm is a farm of conservation practices. Crop rotations improve soil fertility, while strip farming, terraces and contour tillage prevent erosion; gullies are held with vegetation, and surplus water is guided down grassy channels. Steep lands are retired from cultivation and woodlands protected. Electricity lessens the manual labor of farmer and housewife. Wildlife cover furnishes breeding grounds for game and sport for hunters. Conservation farming methods and numerous modern mechanical conveniences make farming a secure and enjoyable way of life.

OUR SOIL RESOURCES

Our nation was not fully aroused to the need of major adjustments in our farm practices until the National Resources' Board issued the summary of our resources in 1934. This report shows that, while our remaining soil resources are vast, the losses that had occurred, owing chiefly to erosion, were appalling. This survey indicates that 57,200,000 acres of cropland, or 3 per cent, have been essentially destroyed for tillage, and that about 144,700,000 acres, or 7½ per cent, consist of mesas, canyons, scablands, badlands, and rough mountain land that had been considerably damaged by overgrazing and erosion. On 12 per cent of the land of the United States, or 225,000,000 acres, erosion has been severe, and more than three-fourths of the original surface soil has been lost. On 775,600,000

[1] United States Department of Agriculture Exhibit, Jan. 10, 1941.

acres, or 41 per cent, erosion has been moderate and from one-fourth to three-fourths of the original surface soil has been lost. On 700,500,000 acres, or 37 per cent, mostly flat, gently undulating, or forested land, erosion has been slight; less than one-fourth of the original surface soil has been lost.

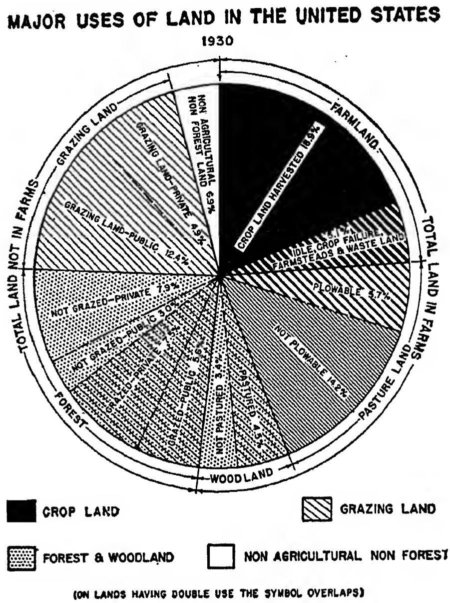


FIG. 10. Major uses of land in the United States (Chapter I). Our total land area is a little less than 2,000,000,000 acres. (*Our National Resources, issued by the National Resources Planning Board.*)

The present cropland area of the United States (1935 Census of Agriculture) is 415,334,931 acres. Of this practically 61 per cent, or 253,000,000 acres, is either subject to continued erosion or is of such poor quality that it does not return a satisfactory income to farmers at the price levels assumed. More than half of this land is particularly in need of good soil-conservation practices to prevent serious damage.

Only about 39 per cent, or 161,000,000 acres, of the present cropland area can be safely cultivated under prevailing practices, or should be cultivated under the price levels assumed. In addition to this, some land (about 50,000,000 acres) that is not now in cultivation could be cultivated safely. It is estimated that under the best crop practices fully 82 per cent, or 339,000,000 acres, of the present

cropland area could be safely cultivated and should yield a satisfactory return at price levels assumed. Even under these practices, however, over 76,000,000 acres, or 18 per cent, of the present cropland area should be retired as submarginal or not suited for production at present.

If the need arises we can do more than compensate for this retired submarginal land, because with the best practices we can cultivate 108,400,000 acres that are now in plowable pasture, brush, or timber, or are improvable by drainage or irrigation. This might be called the nation's production reserve. It increases the potential resources of cultivable land, under the best practices, to 447,466,000 acres, which is a little more than the cropland area of today.

With this survey as a foundation and with consideration for the close relationship of human welfare to soil resources, the objectives of the United States Department of Agriculture were stated as follows in calling for concerted cooperation in a national program.

1. To conserve human as well as physical resources.
2. To bring about proper land use on all crop, pasture, range and timber land.
3. To retard and control soil erosion.
4. To maintain soil fertility and productivity at a profitable level.
5. To thereby bring about better living and better security for both rural and urban people.
6. To protect the water resources of the country—rivers and lakes and reservoirs.

AGRICULTURAL ADJUSTMENT TO CONSERVE THE SOIL

Many phases of the farm program contribute to the conservation of the nation's agricultural resources. Under the conservation and adjustment program about 80 per cent of the farm land and 70 per cent of the privately owned range land were included in 1939 participation. Through the adjustment provisions of the program about 35,000,000 acres of land have been shifted from soil-depleting to soil-conserving uses annually. Included in soil-conserving uses under the 1938 program were 55,000,000 acres of new seedings of soil-conserving crops; 16,000,000 acres of contour farming, contour listing, and controlled fallow; 74,000 miles of terraces constructed; and more than 3000 miles of contour ridging done on pasture land.

Until June 30, 1939, a total of 48,000,000 acres of farm land on 82,000 farms were covered by five-year, cooperative soil-conserva-

tion agreements between farmers and the Department of Agriculture in erosion-control demonstration areas. More than 250 soil-conservation districts were organized under state laws in 37 states by June, 1940. Within these districts, which are operated by farmers, there are more than 120,000,000 acres and more than a million farms. By June, 1940, the department was working actively with 182 districts.

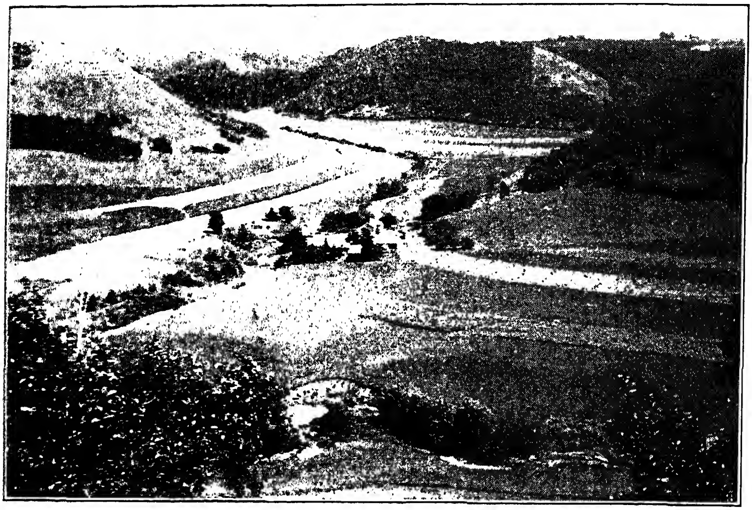


FIG. 11. A land-use program for a valley farm: strips of alfalfa, corn, and small grains grown on the valley floor; forest and grasslands on slopes. (*Soil Conservation Service, U.S.D.A.*)

Range-improvement practices have been employed on approximately 190,000,000 acres, including natural reseeding through deferred grazing on 28,000,000 acres. Under the supervision of the department, grazing on more than 80,000,000 acres of national forest lands is regulated with the assistance of range committees comprised of livestock producers.

In addition to the progress made under the adjustment and conservation features of the national farm program, improved land use has been brought about on 8,500,000 acres of submarginal land purchased and developed principally for forestry and grazing. (This is a portion of the 25,000,000 acres of submarginal land purchased by the federal government since 1933.) Nearly 30,000 ponds have been constructed on range land.[2]

[2] Achieving a Balanced Agriculture, U.S.D.A., Revised, 1940.

EFFECTS OF EROSION ON CROP YIELDS [3]

Calculations based on material furnished by authorities and subsequently reported by the National Resources' Board show that 99,300,000 tons of plant-food materials are lost annually from the surface soil of cropland in the United States, in addition to 37,200,000 tons removed annually from pastured acres. As shown in Table 4, taken from the National Resources' Board report, 22 per cent of the nitrogen losses, 52 per cent of the phosphorus losses, 58 per cent of the potassium losses, 34 per cent of the calcium losses, 49 per cent of the magnesium losses, 10 per cent of the sulphur losses, and 22 per cent of the losses of organic matter are due to erosion.

TABLE 4

Plant Nutrients Annually Lost from Soils of the United States *

Losses through	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium	Sulphur	Organic Matter
	(1000 tons)	(1000 tons)	(1000 tons)	(1000 tons)	(1000 tons)	(1000 tons)	(1000 tons)
Crops (harvested areas)	4,600	700	3,200	1,000	500	500	92,000
Grazing (pastures)	3,000	500	3,700	1,000	500	400	60,000
Leaching (harvested areas)	4,000		6,600	26,600	6,000	7,400	80,000
Erosion (harvested areas)	2,500	900	15,000	13,000	6,000	800	50,000
Leaching (pastures)	1,000		1,700	7,000	1,600	1,900	20,000
Erosion (pastures)	1,000	400	6,000	5,000	2,200	300	20,000
Total	16,100	2,500	36,200	53,600	16,800	11,300	322,000

* Area considered: harvested crops, 365,000,000 acres; pasture and woodland grazing areas, 1,000,000,000 acres.

THE EFFECT OF SOIL EROSION ON FLOODS, NAVIGATION, WATER-POWER DEVELOPMENT, AND WATER CONSERVATION [4]

Observations in the Santa Clara Valley of California show that run-off may increase from 12 to 20 times when the slopes have been stripped of vegetation by fire.

At Tyler, Tex., in a district of gentle slopes with an annual rainfall of 40 inches, clearing and cultivating the land increased the run-off 28 times and the soil losses 239 times (4-year average, 1931–34).

At Bethany, Mo., fallow land typical of the southern portion of the Corn Belt lost 235 times as much soil and 3 times as much water in run-off as similar land covered with grass (5-year average, 1931–35).

[3] "Soils and Men," U.S.D.A. Yearbook, 1938.

[4] *Ibid.*

Land under native grass in the Appalachian hill section near Zanesville, Ohio, lost only 4.5 per cent of the total rainfall as surface run-off. A nearby plot left fallow lost 42.5 per cent, while another plot planted continuously to corn lost 35.2 per cent of the rainfall as run-off (2-year average, 1934–35).

Data obtained at the Guthrie, Okla., Erosion Experiment Station show that the water run-off from land cultivated continuously to cotton was 11 times greater and the soil loss 760 times greater than from the same kind of land covered with ungrazed Bermuda grass (6-year average, 1930–35).

COOPERATIVE LAND-USE PLANNING

To assist farmers in planning the best use of individual farms and to develop coordinated community land-use programs, county and community land-use planning committees have been established in nearly all agricultural counties. The committees of farmers and other persons interested in farming and farm life view the problems

FIG. 12. Aerial photographs and soil maps are of basic importance in community program planning by land-use planning committees in the development of far-sighted extension programs and in shaping farm programs in soil-conservation districts. Note evidences of severe erosion at right that provides a serious problem in the development of a cooperative land-use program for this New York community. (*U.S.D.A.*)

of land-use from broad angles, such as how the people of the community can best use the land to achieve greater prosperity and to advance cultural, economic, educational, and religious interests, and how to correct existing ill-use, prevent erosion, and conserve and build up the land for the present and future generations. The best varieties of crops and breeds of livestock, community roads and schools, noxious weeds, garbage-disposal piggeries, and other nuisances all come up for discussions at the land-use planning meetings and, frequently, constructive community or official action results.

Immediately after the inauguration of the national agricultural defense program, the community land-use committees became powerful forces in directing local thought along channels that lead to the greatest possible local support of the call for increased production of specified crops, dairy, livestock, and poultry products needed in our own defense and by our allied democracies.

With the county committees as a foundation, state land-use planning committees have been formed in all the states to initiate a state agricultural program. The state directors of agricultural extension act as chairman of the state committees, and a representative of the Bureau of Agricultural Economics of the United States Department of Agriculture serves as secretary. The members of the state land-use committees are composed of representative farm men and women and of designated representatives of the State Agricultural Experiment Station, the Agricultural Adjustment Administration, the Soil Conservation Service, the Farm Credit Administration, the Farm Security Administration, the Public Roads and Forestry Services, the Conservation Department, and other state agencies. The development of the land-use planning committees is an outgrowth of an agreement between the Association of Land Grant Colleges and the United States Department of Agriculture, known as the Mount Weather Agreement of July, 1938, which has already proved to be a desirably potent influence upon our democratic institutions.

CHAPTER IV

CROP ADAPTATIONS

The choice of crops to form the foundation of a cropping system is influenced by many factors, such as climate, soil, rainfall or available irrigation water, the livestock feeding program, marketing facilities, and personal choice. Adaptation to soil and climate are primary factors in determining the choice of crops to be included in the rotation system.

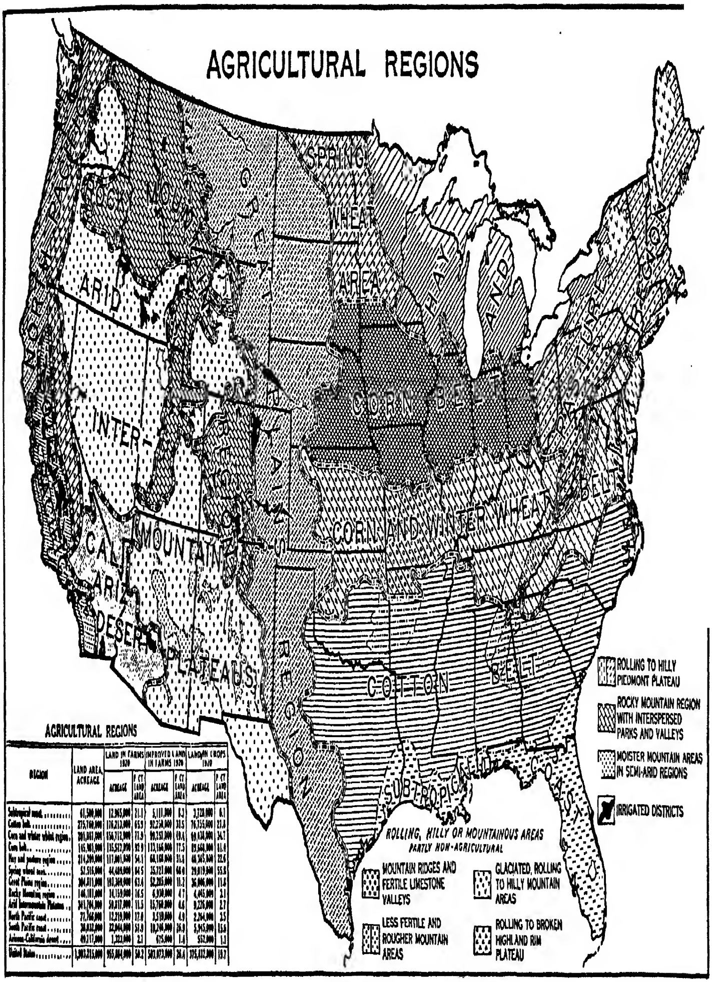
Based on major adaptation of crops and dependent livestock production, the Bureau of Agricultural Economics, after exhaustive production studies, developed the accompanying map, showing the major agricultural regions of the United States (page 39) with regional and subregional classifications of types of farming in the United States. This classification has been used as a guide in developing the agricultural adjustment program.

Recognizing that environment determines the type of farming and the selection of crops, the following brief analysis of the most important conditions and forces shaping agriculture in the major type of farming regions of the United States was prepared by F. F. Elliot, Chief of the Program Planning Division of the Agricultural Adjustment Administration.

REGIONAL AND SUBREGIONAL CLASSIFICATION OF TYPES OF FARMING IN THE UNITED STATES

The following differentiation of the agriculture of the United States is based upon variations in soil, climate, and surface features; crop and livestock combinations; relative productivity; markets; relative income by source; and other minor factors. The map (Fig. 13) has been designed to present a generalized picture of the nation's agriculture. The thirteen regions and one hundred subregions shown on the face of this map are classified as follows:

1. Mixed Farming
   - *A*. Puget Sound, Willamette and Associated Valleys.
   - *B*. Intermountain Irrigated Valleys.
   - *C*. Colorado, New Mexico High Plain.



Region	Land area, acreage	Land in farms 1920 Acreage	P. ct. land area	Improved land in farms 1920 Acreage	P. ct. land area	Land in crops 1920 Acreage	P. ct. land area
Subtropical coast	61,500,000	12,965,000	21.1	5,111,000	8.3	3,728,000	6.1
Cotton belt	275,760,000	176,213,000	63.9	92,250,000	33.5	76,755,000	27.8
Corn and winter wheat region	201,083,000	156,712,000	77.9	99,251,000	49.4	69,634,000	34.7
Corn belt	145,983,000	135,512,000	92.9	113,166,000	77.5	89,660,000	61.4
Hay and pasture region	214,209,000	117,001,000	54.1	68,160,000	31.8	48,365,000	22.6
Spring wheat area	52,516,000	44,409,000	84.5	35,721,000	68.0	29,019,000	55.3
Great Plains region	304,811,000	193,369,000	63.4	52,215,000	17.1	36,006,000	11.8
Rocky Mountain region	146,181,000	24,159,000	16.5	6,930,000	4.7	4,465,000	3.1
Arid Intermountain Plateaus	341,704,000	39,317,000	11.5	15,760,000	4.6	9,226,000	2.7
North Pacific coast	71,766,000	12,219,000	17.0	3,519,000	4.9	2,264,000	2.5
South Pacific coast	38,032,000	22,044,000	57.9	10,246,000	26.9	5,945,000	15.6
Arizona-California desert	49,117,000	1,323,000	2.7	675,000	1.4	552,000	1.1
United States	1,903,215,000	955,884,000	50.2	503,073,000	26.4	375,032,000	19.7

(*U.S.D.A.*)

FIG. 13.

1. Mixed Farming—*Continued*
   D. Finger Lakes.
   E. Atlantic and Gulf Coast Flatwoods.
   F. Miscellaneous City Areas.
2. Fruit and Mixed Farming
   A. Washington, Oregon Irrigated Valleys.
   B. St. Helena, Santa Cruz, and Santa Clara Valleys.
   C. Great Valley of California.
   D. Salinas River Valley.
   E. Southern California Valleys.
   F. Sierra Nevada, Coast Range Timberland and Grazing.
   G. Lower Rio Grande Valley.
   H. Florida Fruit Region.
   I. Lake Michigan, Lake Ontario.
   J. Shenandoah, Cumberland, Albemarle.
   K. Georgia Peach Area.
   L. Miscellaneous Berry and Tree Fruit Areas.
3. Range Livestock
   A. Harney Basin, Blue Mountains.
   B. Utah, Nevada Basin.
   C. Rocky Mountains and Associated Basins.
   D. Northern Great Plains.
   E. Sandhills of Nebraska.
   F. Southwestern Woodlands, Grassland and Semi-Deserts.
   G. Edwards Plateau.
   H. Range Livestock and Cotton.
   I. Flint Hills of Kansas.
4. Wheat and Small Grains
   A. Columbia River Basin—Eastern Portion.
   B. Columbia River Basin—Western Portion.
   C. Southeastern Idaho.
   D. Wheat and Range Livestock.
   E. Wheat and General Farming.
   F. Specialized Wheat and Small Grain.
   G. Wheat and Range Livestock.
   H. Specialized Wheat Farming.
   I. Wheat and General Farming.
5. Dairy
   A. North Pacific Coast
   B. Lake States, Subregion *A*.
   C. Lake States, Subregion *B*.
   D. Lake States, Subregion *C*.

5. DAIRY—*Continued*
   E. Chicago, Milwaukee Milkshed.
   F. Detroit, Lansing Milkshed.
   G. New York, Subregion *A*.
   H. New York, Subregion *B*.
   I. New York, Subregion *C*.
   J. Boston Milkshed.
   K. Miscellaneous Dairy Areas.
6. CORN BELT
   A. Western Transition.
   B. Northern Livestock Dairy
   C. Cash Corn and Oats.
   D. Cash Corn and Small Grain.
   E. Central Intensive Feeding.
   F. Southern Pasture and Feeding.
   G. Cash Corn and Small Grain.
   H. General Farming, Dairy and Crop Specialties.
   I. Livestock and Soft Winter Wheat.
7. GENERAL FARMING
   A. Ozark, Southeast Kansas, Oklahoma.
   B. Southern Illinois and Indiana.
   C. Eastern Ohio and Middle Atlantic States.
   D. Central Basin of Tennessee.
   E. Virginia, West Virginia Grazing Regions.
   F. Tennessee, Shenandoah, Cumberland Limestone Valleys.
8. COTTON BELT
   A. Southwestern Irrigated Valleys.
   B. Large-scale Cotton Farming.
   C. Oklahoma, Texas General Farming.
   D. Arkansas River Valley and Uplands.
   E. Black Waxy Prairie of Texas.
   F. Post-Oak Strip, Upper Coastal Prairie.
   G. Piney Woods of Northeast Texas.
   H. Southwestern Arkansas and Northern Louisiana.
   I. Mississippi, Alabama Clay Hills and Rolling Uplands.
   J. Southeast Texas, Mississippi Piney Woods—Cotton and Self-sufficing.
   K. Mississippi and Red River Deltas.
   L. Mississippi, Tennessee Brown Loam Area.
   M. Tennessee River and Limestone Valleys.
   N. Northern Piedmont.
   O. Southern Piedmont.

8. Cotton Belt—*Continued*
   P. Gulf Coastal Plain—Cotton and Peanuts.
   Q. Eastern Coastal Plain and Sandhills.
9. Self-Sufficing
   A. Southern Appalachian Region.
   B. Ozark, Ouachita Mountains.
10. Special Crops
   A. Ripe Field Beans.
   B. Sugar Beets.
   C. Sugar Cane.
   D. Potatoes.
   E. Rice.
   F. Peanuts.
11. Tobacco and General Farming
   A. Burley.
   B. Flue-cured.
   C. Fire-cured.
   D. Dark Air-cured.
   E. Southern Maryland.
   F. Cigar Types.
12. Truck
   A. Imperial Valley and Winter Garden of Texas.
   B. Southeastern Truck Regions.
   C. Baltimore, Philadelphia, New Jersey.
13. Nonagricultural
   A. Cascade Mountains and Associated Coast Ranges.
   B. Adirondacks and Northern Maine.
   C. Colorado, Mohave Desert.
   D. Florida Flatwoods and Everglades.

THE CORN BELT OF THE UNITED STATES

The Midwest, the great corn-livestock region, is a country of level or gently undulating, deep, warm, black soils, naturally rich in lime, nitrogen, and organic matter. These fertile soils, the long growing season, and ample, well-distributed rainfall provide the best conditions in the world for the growing of corn and the feeding of hogs, beef cattle, dairy cattle, sheep, and poultry. Wheat, oats, barley, rye, and bluegrass, clover, alfalfa, and other legumes and grasses thrive under Corn Belt conditions. This region has been termed the bread basket of America.

GENERAL FARMING REGION

Between the Cotton Belt in the South and the Corn Belt and dairy regions in the North, lies a great territory where climate and soil combine to produce conditions adapted to a variety of enterprises. Corn, wheat, and hay predominate. This region includes the blue-grass country of Kentucky and Virginia; the dairy, tobacco, and

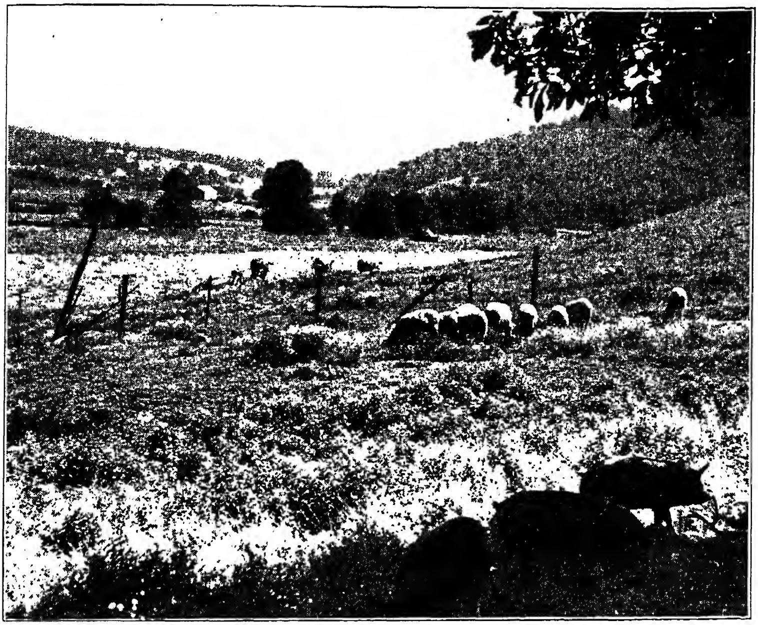


FIG. 14. A general farm devoted to crops and livestock. The slopes bordering this valley are used best for pasture and woodlot purposes. (*U.S.D.A.*)

truck-crop regions of Maryland and Delaware; and the splendidly balanced crop and livestock farming development of Missouri, Kansas, and Tennessee.

THE COTTON BELT

Cotton has been the dominant crop of this great region south of the general farming region of the Corn-Wheat Belt where high temperatures, increasing during the growing season, prevail. Whereas cotton is king in the southeastern quarter of the United States, corn, winter wheat, winter oats, and a great variety of grasses and legumes,

sweet potatoes and peanuts, tobacco and truck crops enable this region to maintain the most intensive population on the land in the United States.

THE WHEAT REGIONS

Northwest of the Corn Belt lies the hard spring wheat area of Minnesota, and the eastern half of the Dakotas. This region of moderate rainfall and prairie soils produces the finest type of milling wheat, but is also adapted to the production of corn, sorghum, clover and alfalfa, bromegrass and timothy, and hence has become a great livestock and dairy country. To the southwest of the Corn Belt in Nebraska, western Kansas and Oklahoma, a region of lower rainfall, winter wheat is the leading crop. The sorghums, which resist drought, are more important than corn. Alfalfa and Sudan grass contribute to the roughage supply and, with the native range pasture, maintain a high level of livestock production in this region.

THE DAIRY REGION

The New England States, Pennsylvania, and the Middle Atlantic States, northern Ohio, southern Michigan, northern Indiana and Illinois, Wisconsin and Minnesota, with the Great Lakes a major influence, constitute the major dairy-producing region of the United States. Sufficiently productive soils, ample and well-distributed rainfall, and proximity to great centers of population are the chief reasons for the predominance of milk production in this area. Grass for pasturage, legumes and grass for hay, corn for grain and ensilage, soybeans and root crops provide ample dairy, livestock, and poultry feed. Truck and garden crops and special crops, such as sugar beets, beans, and fruit crops, contribute to the diversity of the agricultural wealth of this region. Seed crops of vegetables and major truck crops are extensively produced.

THE WESTERN RANGE REGION

The Great Plains region, mountain and Great Basin country west of the Wheat, Corn, and Cotton Belts extends from Canada to Mexico. The long-grass region of the North and the short-grass of the Mid-section and South provides one of the most important livestock-grazing areas and breeding areas of the world. The rainfall is low and uncertain and not sufficient for the extensive production of grains and truck crops, fruit, or special crops except under irrigated condi-

tions. In the main, this region is best adapted to grass and the production of wheat. Corn and cultivated crops and forage crops, where water is not provided by irrigation, have been short-lived and the production of these crops has resulted in extensive disaster and serious wind erosion.

FRUIT AND TRUCK REGION

The specialized fruit and truck areas of Florida and the territory bordering the Gulf, the Great Lakes, Southern California, and the eastern shore of Maryland, and Virginia, New Jersey, and Long Island are characterized by climates that are influenced by great bodies of water and sandy loams and loamy soils. The citrus fruits are confined to limited districts in Florida, Texas, and California. The dry atmosphere and sunshine of California are adapted to the drying of fruit.

SPECIALIZED CROPS

Special crops are widely distributed throughout the major farming areas of the United States. Late potatoes do best in a cool climate with ample rainfall, where light loams and sandy loams prevail. Maine, New York, the Great Lakes States, and Idaho produce the majority of our late potatoes. Early potatoes are produced in greatest amounts from Florida to Long Island. Sugar beets are produced in the Great Lakes States, California, Colorado, and Idaho, where ample rainfall or irrigation water provides for the high moisture need for this crop. The prevailing temperature for the maximum growing season of sugar beets during June, July, and August averages 70 degrees Fahrenheit. Sugar cane requires a warm climate and copious rainfall and is grown chiefly in Louisiana and Florida. Field beans are adapted to the Great Lakes Region of Michigan and New York and grown under irrigated or dry-land farming conditions in Colorado, New Mexico, Idaho, and California.

Farmers must know the origin of seed of alfalfa, clover, corn, soybeans, cowpeas, and many other crops. The alfalfa varieties of the southwestern United States are not adapted to growing in the Corn Belt and Northern States. Grimm and hardy northern alfalfa varieties do not do well in Southern States. Northern red clover seed is not as well adapted as their own disease-resistant varieties to Tennessee and Virginia. Soybean varieties adapted to Indiana and Illinois are not adapted to Alabama and Mississippi. Corn varieties, hybrid or open-pollinated, have a limited range of adaptation. A successful

Corn Belt variety may prove a failure when planted in the Great Lakes region or in the Cotton Belt. The Rosen rye is a great yielder in Michigan but is not adapted to Georgia or other Southern States where the abruzzi rye is generally grown because of its superiority in producing winter cover. Tobacco, potatoes, sorghums, and many other crops differ greatly in varietal adaptation to soil and climate.

LENGTH OF DAY INFLUENCES PLANT GROWTH

One plant variety or strain may flower and fruit weeks or months in advance of another variety planted on the same date. Some species when transported from the tropics to high latitudes grow with extraordinary vigor and attain great size but lose the power to blossom and set seed. Plant physiologists in the United States Department of Agriculture have found that plants vary greatly in their day length and sunlight requirements.

These investigators found that a newly discovered Maryland variety of tobacco continued to grow vigorously through the growing season and produced excellent yields but failed to flower. When grown in the greenhouse during the winter months, this variety readily flowered and set seed. Certain late-maturing varieties of soybeans, whether planted early or late, always produced flowers at a certain time in early fall. Failing to find any relation between these observations and the seasonal changes in temperature, light intensity, or humidity, the scientists tried artificially shortening and lengthening the daily light period. The results proved it to be easy to induce or suppress reproductive activity. Tests on many other plants showed that response to changes in day length is not limited to flowering and fruiting but includes the formation of tubers, leaf development, and branch and stem growth.

By proper regulation of the daily period of light under controlled conditions and by providing suitable conditions of temperature and other environmental factors, it is now possible to control the rate, amount, and nature of the growth of plants.

REFERENCE

Climate and Man—U.S.D.A. Yearbook, 1941.

CHAPTER V

PLANNING CROP ROTATIONS FOR THE FARM

The planning of crop rotations, accompanied by the mapping of the fields, is important in determining the production of crops, livestock, and poultry and the conservation and the improvement of soils. Before the development of the Agricultural Adjustment program and the establishment of the soil-conservation districts, the definite planning of rotation practices was limited to farmers and cooperators in the farm-management programs of the agricultural colleges and extension services and to the small number of far-sighted farmers who realized the importance of establishing their cropping program on a basis that would maintain fertility, provide pasture and feed for livestock, and produce cash crops under conditions that would insure high yields per acre and reduce labor costs. A great majority of farmers are content to accept field arrangements as they find them and to make their plantings under the pressure of the seasons, with little consideration to economy of production, a continuous feeding program for livestock, soil conservation and improvement, or the prospective market situation.

The foresighted farmer, by planning his field arrangements often, will reduce greatly the cost of production and will arrange for the planning of crops in sequence, over a stated period of years. These crops will prepare the way for the following crops at a minimum of cost in plowing and cultivating. The inclusion of a proper system of liming and fertilization will contribute to the conservation and improvement of the soil. Legumes and winter cover crops and, oftentimes, green-manuring crops, rotation pastures, and emergency forage crops can be included in the program.

The testing of soils that will determine the needs of lime, phosphorus, potash, nitrogen, and other elements of fertility is of basic importance. In almost every state satisfactory soil tests and recommendations as to fertility improvement can be secured by cooperating with the county agricultural agent. Where it is found advisable to introduce new legumes, such as alfalfa, soybeans, lespedeza, winter vetch, and winter peas, inoculation of the seed or soil with the proper bacterial culture will be necessary.

In a properly planned rotation system it is possible to arrange for a large part of the harvest of corn, small grains, forage, and pasture crops by the grazing in the field by cattle, sheep, hogs, and poultry, thus reducing harvest costs, the cost of feeding livestock, and the handling of manure. The efficiency of modern farm machinery is in-

FIG. 15. An example of community agricultural conservation in South Carolina. Cooperating in the nation's Agricultural Conservation Program, the great majority of American farmers has adopted soil-conserving practices, such as contour farming, strip cropping, terracing, the inclusion of soil-conserving and soil-building crops in rotation, liming and phosphating, and other practices that improve and conserve the soil and increase farm income. (*U.S.D.A.*)

creased on large fields; the cost of preparing land, cultivating and harvesting crops, is reduced by enlarging the scope of fields, by cutting down on the time lost in turning at the ends of the field, and by reducing the wasteland of field borders and fence rows.

The planning of adequate field arrangements in crop rotation insures profitable crop and livestock-feed production at minimum costs and the enriching of farm land for increased future production. On the contrary, failure to plan the cropping system, field arrangement, and system of fertilization may lead to soil depletion, high production costs, and inadequate returns from crops and livestock. Adequate crop management, accompanied by a fertility and cover-crop pro-

gram adapted to the soil, means the constant improvement of the farm plant and the building of a valuable heritage. Haphazard annual field and planting programs often tend to reduce the productive value of farm land and in the course of years result in serious soil depletion.

PLANNING THE FIELD ARRANGEMENT

In the beginning, American farms either were hewn from the forests or else the tough sods of centuries were plowed to provide needed crop land. The size of the field cleared each year depended upon available labor. It was the custom to fence each field, as cleared, to protect crops from cattle's grazing at large in the woods or on the plains. These fence lines, once established, remained as a permanent influence for generations, and the field size of the average American farm in many cases ranges from a few to many acres, making it difficult to plan three-, four-, or six-year rotations unless fence lines are readjusted and fields of uniform size, soil type, and topography are established. If attention has not been given to the mapping of the farms, the proper arrangment of fields, this should be done as a primary step in choosing crops to be planted in connection with the livestock-feeding program, the cash-crop program, and the protection of soil losses from erosion and the increase of organic matter in the soil.

In the efficient use of modern machinery, fields of 20 or more acres in size are advisable for reducing the waste of the land along fence rows and for reducing time loss in land fitting, cultivating, and harvesting processes. The square- or rectangular-field system is not adapted to "conservation farming" in rolling or hilly country.

SELECTING CROPS AND PLANNING ROTATIONS

In choosing crops to be grown on the farm, many factors must be considered. The primary factors are, of course, adaptation to soil and climate and the cash return that can be secured through growing crops for livestock feeding and cash sales. Farming is a business operation, and the profits secured determine the security, the standards of living, and the opportunity of the family that is operating the land. The adaptation of crops to the soil, to the pasture, to the hay and roughage and grain needs of livestock maintained on the farm, to the growing of legumes and grasses that prevent erosion and increase organic matter and nitrogen, to the distribution of labor

throughout the year, to the reduction of the cost of fitting land by reducing plowing to a minimum, to the harvesting of crops by direct pasturage and the application of lime, to fertilizer and manure in the cheapest and most efficient manner—all are factors that must be considered in planning crop rotations over the period of years deemed most advisable.

STANDARD ROTATIONS

Perhaps the simplest rotation adapted to the greatest range of farming conditions is the three-year rotation, consisting of cultivated crops, such as corn, tobacco, potatoes, cotton, or truck crops, during the first year. These crops require plowing and a thorough fitting and cultivating of the land. After their removal they may be followed by either a fall- or spring-planted crop of small grain, such as wheat, rye, oats, or barley. If the cash crop is removed in time for fall planting, then winter wheat, winter rye, or winter oats or barley may be planted. The fall-planted grain crops are of value in preventing erosion or leaching during fall, winter, and early spring. The small-grain crops are seeded to legumes and grasses, such as clover and timothy, sweet clover, or lespedeza. These crops are used during the third year for hay and pasture and contribute to the improvement of the land through additions of nitrogen and organic matter by the legumes and of humus by the grasses. In this rotation one plowing of the land suffices for three years of crop production under most conditions. Mineral fertilizers, such as superphosphate or mixed fertilizers, are applied when corn or small grains are planted. Manure is best applied to the sod land during the fall, in preparation for corn the following year. Lime is best applied either to the sod or when fitting the ground for corn planting.

A standard four-year rotation is as follows: first year, cultivated crops; second year, small grains seeded to legumes and grasses; third year, hay; fourth year, hay or pasture. Many farmers choose to combine two three-year rotations into a six-year rotation in order to control diseases, carried in the soil, that affect potatoes, sugar beets, corn, and cotton. Such a six-year rotation is as follows: first year, corn; second year, small grains; third year, clover, sweet clover, or lespedeza; fourth year, potatoes, sugar beets, tomatoes, or other truck crops; fifth year, small grains; sixth year, clover, lespedeza, or sweet clover.

Where alfalfa is included in rotation, it is usually allowed to remain on the land for three years; or a field not included in a planned se-

quence of rotation is chosen for alfalfa, which is allowed to remain for five, ten, or more years if yields continue to be satisfactory. A common rotation, including alfalfa, is the following: first year, corn or other cultivated crops; second year, small grain seeded to alfalfa; third to sixth year, alfalfa. When alfalfa sods are turned under, two years are frequently devoted to corn or other cultivated crops before small grains, seeded to grass and legumes, are planted.

The following are standard rotations commonly used in various regions of the United States.

North Central or Corn Belt Rotations. First year, corn; second year, wheat, oats, or rye; third year, clover, lespedeza (southern Corn Belt).

Four-year rotation: corn, second year, small grain, seeded; third year, clover and timothy or clover, timothy and redtop; fourth year, clover and timothy, or clover, timothy, and redtop.

Southern or Cotton Belt Rotations. First year, cotton, followed by winter cover crops of winter peas, winter vetch or abruzzi rye or winter oats or winter barley; second year, corn, and fall-planted winter cover crops; third year, lespedeza, burr clover, dallas grass. This rotation may be expanded to a four- or five-year rotation by leaving the established lespedeza or dallas grass for one or two years.

East Central Rotations. First year, corn, tobacco, potatoes, or cultivated truck crops; second year, fall-planted oats, wheat, barley, or rye; third year, clover, crimson clover, lespedeza, or clover and timothy. This rotation can be expanded to four years by continuing the clover, clover and timothy, or lespedeza for an additional year for hay and pasture use. Tobacco is frequently not included in a planned rotation but is planted on a field that has lain fallow for several years, covered by native growth of ragweed, pigeon grass, and other native weeds. The native weeds apparently contribute to the quality and yield of tobacco. In many instances the growing of lespedeza clover and other legumes in rotation may tend to increase the organic matter and nitrogen to such an extent that the quality of tobacco is impaired and the rust increased.

Northeastern States Rotations. Owing to the importance of dairying, crops that provide pasture, hay, and ensilage are of great importance. The following rotations are commonly employed in this region: first year, corn, potatoes, and truck crops; second year, oats or barley, spring planted; third year, hay, alsike, red clover, timothy

and ladino, and white clover; fourth year, hay and pasture. The four-year rotation may be lengthened to five or six years by continuing the use of the hay and pasture.

Truck-Crop Rotations. First year: potatoes, sweet corn, snap beans, melons or cucumbers or other truck crops, followed by a fall

FIG. 16. Field arrangements and the cropping system on this Michigan farm have been planned to conserve the soil. Corn, oats, barley, and alfalfa are rotated in strips. Plowing and cultivating follow the contours. Permanent fences are being rapidly replaced by electric fences and other temporary fences erected as needed in pasturing crops in rotation. (*U.S.D.A.*)

planting of rye or of rye and vetch to be turned under the following spring; second year, corn or truck crop; third year, winter wheat or winter rye, seeded to clover and timothy; fourth year, hay and pasture.

Northwestern Rotations. First year: corn, sugar beets, potatoes, or other cultivated crops; second year, spring wheat or spring rye, flax or barley, seeded to alfalfa, sweet clover, crested wheat grass, bromegrass, or grass and legume mixtures; third year, hay and pasture; fourth year, hay and pasture. This rotation may be made a five- or six-year rotation by continuing the use of hay and pasture for one or two additional years.

Southwestern Rotations. First year: field beans, corn, truck crops, followed by winter wheat, winter rye or winter barley or spring-planted oats, spring barley or flax seeded to alfalfa, sweet clover, hubam or annual sweet clover.

Under irrigated conditions in western regions, cultivated crops, such as sugar beets, beans, peas, corn, melons, and truck crops are fre-

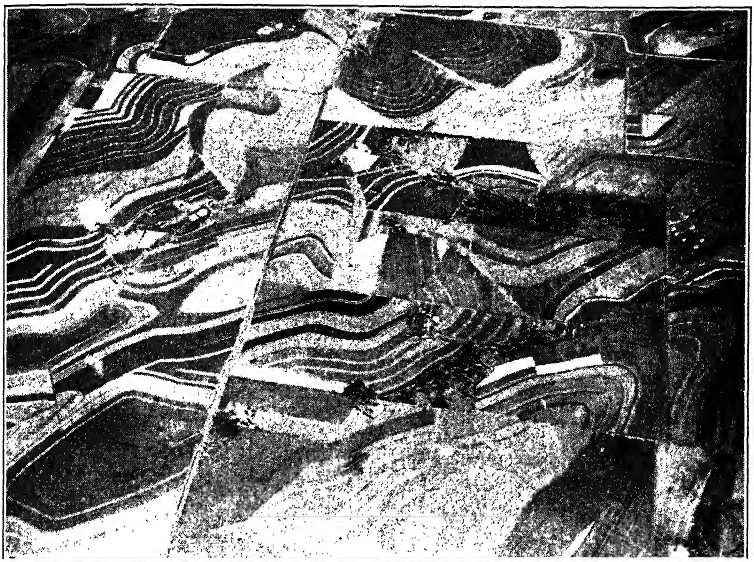


FIG. 17. Airplane view of a Texas soil-conservation district. The farmers of the district cooperate in employing soil-conservation practices, such as strip cropping, terracing, contour farming, and in enlarging the acreage of soil-conserving crops grown in rotation. (*Soil Conservation Service, U.S.D.A.*)

quently grown for two years in sequence, with a winter cover crop of rye and vetch intervening if cultivated crops are followed by small grains or flax seeded to alfalfa, wheat, clover or sweet clover, and grass mixtures.

STRIP-CROP ROTATIONS FOR SLOPING LANDS

Rotation practices must be adjusted to programs of strip cropping where a good farm program requires the growing of crops in strips following the contours. Gustafson and Goodman of the New York State College of Agriculture advise the following four-year dairy-farm rotation with crops grown in contour strips.

The best width of strip to use depends upon the nature of the soil, the steepness of the slope, and the rotation of the crops grown. Strips may be wider on well-drained soils than on poorly drained soils and on gentle slopes than on steep slopes. They may be wider, also, on land on which crops are growing in rotation than on land that is producing clean tilled crops such as potatoes, corn, beans, and cabbage much of the time. This is particularly true when the rotation contains a high proportion of oats, wheat, and legume and grass mixtures. Contour strips should seldom be more than 6

Strip	First Year	Second Year	Third Year	Fourth Year
		First Field or Series of Strips		
1	Potatoes	Oats	Clover	Timothy
2	Clover	Timothy	Potatoes	Oats
3	Potatoes	Oats	Clover	Timothy
4	Clover	Timothy	Potatoes	Oats
5	Potatoes	Oats	Clover	Timothy
6	Clover	Timothy	Potatoes	Oats
7	Potatoes	Oats	Clover	Timothy
8	Clover	Timothy	Potatoes	Oats
		Second Series		
9	Oats	Clover	Timothy	Potatoes
10	Timothy	Potatoes	Oats	Clover
11	Oats	Clover	Timothy	Potatoes
12	Timothy	Potatoes	Oats	Clover
13	Oats	Clover	Timothy	Potatoes
14	Timothy	Potatoes	Oats	Clover
15	Oats	Clover	Timothy	Potatoes
16	Timothy	Potatoes	Oats	Clover
		Small Farm		
1	Potatoes	Oats	Clover	Timothy
2	Timothy	Potatoes	Oats	Clover
3	Oats	Clover	Timothy	Potatoes
4	Clover	Timothy	Potatoes	Oats
5	Potatoes	Oats	Clover	Timothy
6	Timothy	Potatoes	Oats	Clover
7	Oats	Clover	Timothy	Potatoes
8	Clover	Timothy	Potatoes	Oats

rods or 100 feet in width and under the more erosive soil conditions one-half of this width or even less checks erosion to good advantage.

The preceding is a good, representative arrangement for a four-year dairy-farm rotation in which such crops as corn, beans, or cabbage may take the place of potatoes as shown on page 54.

ILLINOIS ROTATIONS

The Extension Service of the University of Illinois prepared the following Work Sheet for Planning a Cropping System, to aid farmers in making acreage adjustments and in choosing soil-building practices under the AAA Agricultural Conservation Program:

A. Consider.

1. The soil—(type; limestone, phosphorus, and potassium needs; slope; amount of erosion; and productivity).
2. The most practical field arrangement.

B. Select Crop Rotations. Variations in soils or in field arrangement may make it necessary to apply two or more rotations to the same farm. How often does your cropland need to be in legumes and grasses to maintain productivity and control erosion: 1 year in 2 or 2 years in 4? 1 year in 3? 1 year in 4? 1 year in 5? How often can it be plowed without causing excessive erosion?

Basic Rotations.

a.	wheat	legume				1 year legume in 2.
b.	corn	small grain	legume			1 year legume in 3.
c.	corn	small grain	wheat	legume		1 year legume in 4.
d.	corn	corn	small grain	legume		1 year legume in 4.
e.	corn	small grain	legume and grass	grass and legume		2 years legume in 4.
f.	corn	corn	small grain	wheat	legume	1 year legume in 5.

2. *Substitutions in Basic Rotations.* (To maintain field system and meet allotments.)

For Corn—soybeans; sorghums; and for first-year corn, wheat (with or without sweet clover catch crop).

For Small Grain—any spring-sown small grain (sometimes winter wheat); sometimes soybeans in Rotation *f;* biennial legume seeded alone.

For Winter Wheat killed out—spring wheat; other spring small grains; or legumes and grasses seeded alone.

For Legumes—any legume or grass or mixtures of them best suited to your farm; soybeans for plowing under; emergency hay or pasture crops.

3. *Split Rotations.* A field may be divided and a crop substituted in a part of it that will permit the field to keep its place in the rotation. For example, if either Rotation *d* or *f* is used on a farm and the corn allotment is less than the two fields, only a part of the field for first-year corn need be plowed up and planted. The remainder will be left in grasses and legumes carried over from the year before.
4. *Flexibility* is necessary for making adjustments to meet allotments or damage caused by weather or insects. This may be done by using substitutions shown in No. 2 above and by using split rotations as indicated in No. 3 above. The conserving acres of a rotation may be increased by seeding perennial grasses with "legumes" and leaving the field down for more than one or two years.

C. Other Steps in Farm Planning.

1. Estimate the feed requirements for your livestock for the coming year. Knowing what you will need will be a guide toward a better use of all crops produced.
2. Estimate probable receipts, expense, and net income.

CONSERVATION PLANNING ON A TEXAS FARM

In discussing conservation planning in a recent publication of the Soil Conservation Service (Working Plans for Permanent Farms, United States Department of Agriculture, Miscellaneous Bulletin 411), Mr. Glenn K. Rule describes the planning and execution of a conservation program on the Blau farm of 1280 acres in the Texas Panhandle.

In a general way the Blaus have put the main body of their land to its best use. However, the use of the old square system of farming (refer to Fig. 18) left the pasture areas in a square or rectangle design, which did not harmonize with the topography of the land or put each acre to its best use. For example, the pasture in the west section was laid out in straight lines. On the north and west side of this pasture were 29.7 acres of gullied, cultivated land that should have been retired to pasture. The old fence is to be removed and a new fence will be built on the contour when grass takes hold on the retired area. Similarly, just across the line in the east section is a 29-acre strip that is retired to pasture.

If you check the figures for the areas in cultivation, pasture, and other uses, before and after the farm was rearranged, you get the composition shown in Table 5.

When the plan is fully completed and in operation all the 832 acres in cultivation will be terraced and farmed on the contour (Fig. 19). The cropping plan to be followed will be a flexible system of wheat, grain sorghums, and fallow.

LAND USE PRIOR TO CONSERVATION PLANNING

THE BLAU FARM

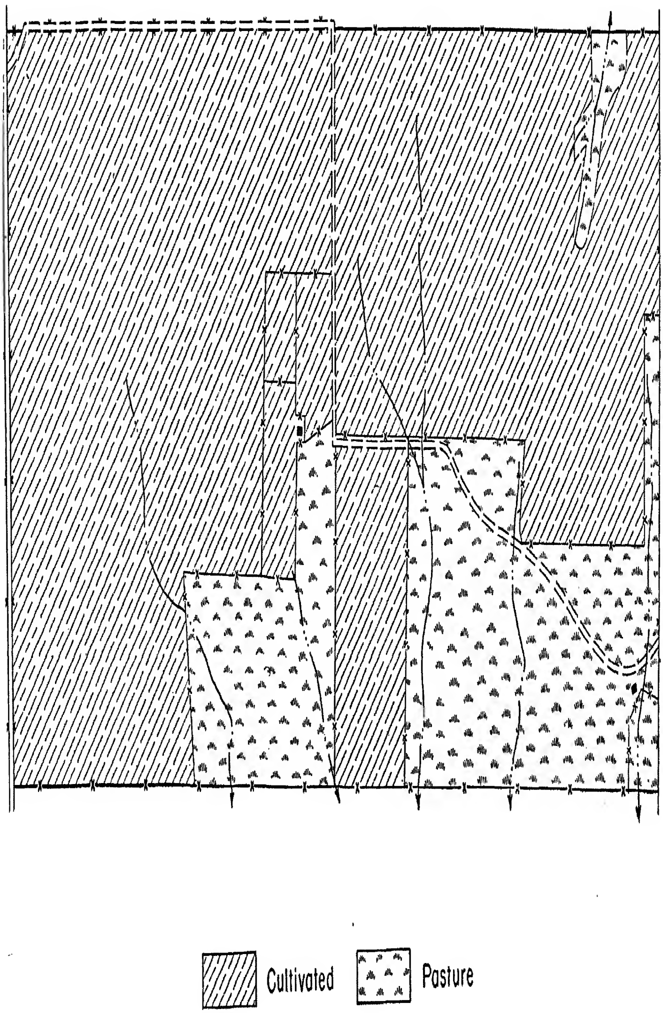


FIG. 18.

LAND USE AFTER CONSERVATION PLANNING

THE BLAU FARM

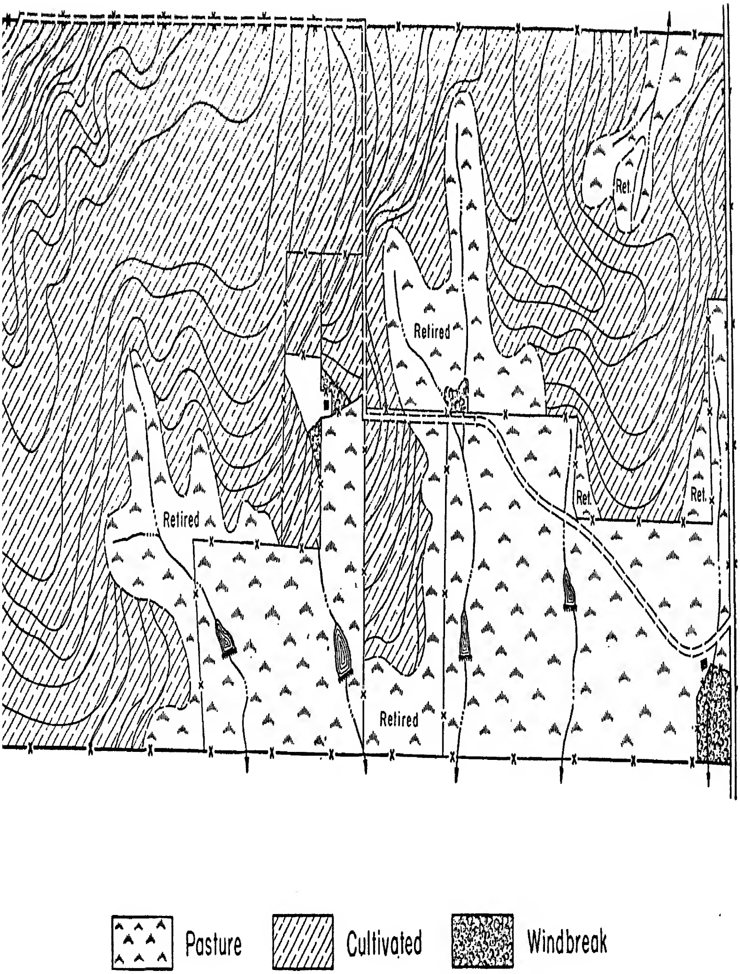


Fig. 19.

TABLE 5

Showing the Shift in Land Use on the Blau Farm through Conservation Planning

Item	Before	After	Net Change
	(Acres)	(Acres)	(Acres)
Cultivated	950.9	832.0	−118.9
Pasture	297.5	407.1	+109.6
Windbreaks	0	9.3	+9.3
Roads, lots, etc.	31.6	31.6	0
Total	1280.0	1280.0	0

CHAPTER VI

MAINTAINING AND IMPROVING SOIL FERTILITY

Placing soil fertility on a permanent or continuing basis of maintenance and improvement is accomplished at a minimum of cost by supporting carefully planned rotations with applications, as needed, of lime, mineral fertilizers, manure, and straw or other crop residue. The rotation should include leguminous crops, covering green-manuring crops, or rotation pasture with sufficient frequency to maintain or increase nitrogen and organic matter in the soil. Manure and straw are most conveniently applied on pasture or clover sods before plowing for cultivated crops or may be applied as a top dressing on wheat or rye. Lime is most economically applied when fitting the seed bed for corn or as a top dressing on sod to be turned under. The amount used should be determined by testing the soil. Usually a 2-ton application of limestone will prove effective for eight or ten years. The phosphate needs should also be determined by test. Four or five hundred pounds of acid phosphate per acre will take care of the phosphate needs of most soil for a period of four years or longer. Acid phosphate and complete fertilizers are generally applied by fertilizer attachments to drills used in planting corn and grain. Applications of 150 to 200 pounds of superphosphate per acre or 200 to 300 pounds of complete fertilizer, applied when planting corn, wheat, or oats in rotation, are suggested.

Rotation pastures maintained for several years are benefited by applications of several hundred pounds of superphosphate or complete fertilizer. Average soils usually contain sufficient potash, which is made available if the content of organic matter in the soil is maintained. If it is found by testing the soil that potash is needed, applications of 100 pounds of muriate or sulphate of potash per acre, applied to corn and small grains, is suggested; or complete fertilizer, well supplied with potash, such as a 4–8–12 fertilizer, should be applied.

In adequate rotations that include legumes, green manuring, and cover crops, supported by the return to the land of manure and straw, the nitrogen supply is generally maintained; but where needed, proper application of complete fertilizer and nitrates should be made.

If land is poorly drained, tile drainage should be included as necessary in a system of soil improvement.

GENERAL INFORMATION

The following statements deal with the nitrogen cycle, the loss of organic matter and its restoration, the relationship of soil to plant and animal nutrition, and the living organisms of the soil.

FIG. 20. A crop of kudzu is usually the first step in reclaiming severely depleted and eroded soils throughout the South.

THE NITROGEN CYCLE[1]

First: Plants and animals die after living during a certain period of time. The plant and animal structures and tissues consist of the various chemical elements derived from the soil, water, and air.

Second: Decay, decomposition, or putrefaction follows the death of plants and animals. Bacteria and other low forms of life live upon the dead organic matter and in so doing bring about the decay of the material. In the process, the carbohydrates, proteins, and fats formed by the plants and animals are reduced to simpler compounds.

[1] From Cox and Jackson, "Crop Management and Soil Conservation," pp. 106–107.

Third: Nitrogen, which is a part of the complex proteins in plants and animals, is reduced to a rather simple nitrogen compound called ammonia. The odor of ammonia is often found about stables. Such an odor means that compounds containing nitrogen are changing into ammonia compounds. The process is sometimes called ammonification. Much nitrogen is often lost from manure in the form of ammonia gas.

Fourth: If conditions are right, the ammonia compounds containing nitrogen are changed by a bacteriological process called nitrification into compounds known as nitrites.

Fifth: The nitrite compounds are changed to nitrate compounds as the next step in the process. It is in the form of nitrates that most crop plants take in nitrogen. Nitrates are soluble in water and consequently are available to plants through their root systems. If plants are not in process of growing, available nitrates may be removed in the soil water as it drains away. This fact indicates how important it is to keep the land covered by growing crops in order to save the dissolved plant food from being lost in the drainage water.

Sixth: Plants use the plant food elements, nitrogen in the form of nitrates for example, in their plant growth. The plants grow to maturity and die, or the plant and its products may be consumed by animals. At the death of the plants and animals the process begins again.

The minerals that constitute the tissues of plants and animals pass through a cycle similar in many ways to the nitrogen cycle, with the exception that there are no renewals of minerals from the air. Plants take minerals needed for their growth from the soil. Animals, feeding on plants, in turn utilize these minerals in their development. Then, when animals or plants die, the minerals carried in their tissues are returned to the soil. While no additions to the minerals of the soil are made under Nature's cycle, mineral elements, brought from the subsoil in soil water or secured by deep-foraging roots, may be translocated to the surface soil levels in the natural cycle of the growth and death of plants and animals.

LOSS OF SOIL ORGANIC MATTER AND ITS RESTORATION[2]

Supply of Virgin Soil Organic Matter Decreasing

The depletion of the supply of organic matter by cultivation is well illustrated by the report of a study made by Jenny in central Missouri in which an undisturbed virgin prairie soil was compared to an adjoining field cropped to corn, wheat, and oats for 60 years without the addition of manure or fertilizer. No erosion had taken place, yet 38 per cent of the organic matter represented by the virgin soil had been lost during that period be-

[2] From "Soils and Men," Yearbook of Agriculture, 1938.

cause of cultivation. As a consequence of this loss in organic matter, the soil structure was modified to an extent that might be represented by reducing the number of granules that were the size of particles of sand by 11 per cent and increasing the number that were the size of clay particles by 5.5 per cent. The loss of organic matter represents soil compaction, which hampers the circulation of air and water and hinders tillage operations at

FIG. 21. A Vermont alfalfa field. The widespread use of lime and phosphate under the Agricultural Conservation Program has greatly increased the acreage of alfalfa. (*U.S.D.A.*)

the same time that the function of the soil in plant nutrition is disturbed. Thus, in but 60 years, more than one-third of the organic matter, representing centuries of accumulation, was destroyed and the efficiency of the soil for crop production was reduced.

PHOSPHORUS DEFICIENCY AND SOIL FERTILITY[3]

DEPLETION OF SOIL PHOSPHORUS THROUGH CROP PRODUCTION AND SOIL EROSION

. . . . In a livestock or grain system of farming the products sold contain large amounts of phosphorus. The cereal grains contain about 75 per cent of their total phosphorus in the seed. When the grain is sold off the farm, therefore, about 75 per cent of the phosphorus that the plants ob-

[3] From "Soils and Men," Yearbook of Agriculture, 1938.

tained from the soil is lost. It should be emphasized also that the phosphorus removed by crops is the most available and therefore the most valuable portion present in soils.

Under a livestock system it has been estimated that about 30 per cent of the phosphorus in the feed is absorbed by the animal and another 20 per cent is often lost in the manure. This means that only about one-half the phosphorus fed in the crops grown is returned to the soil in manure. Of interest in this connection are the following statements of Thorne, one of the pioneers in the study of the maintenance of soil fertility:

> Seven 1000-bushel carloads of corn or oats, or five such carloads of wheat, carry away as much phosphorus as is found in the plowed surface of an average acre of land, even though the stover and straw are conscientiously returned to the land; and ten 13-ton carloads of mixed hay, or half that quantity of alfalfa hay, carry as much phosphorus as seven carloads of corn.
>
> Some farmers assume that, if the hay and most of the grain are fed on the farm, there will be no loss of fertility; but the animal must find in its food the elements required to build its skeleton and other tissues. Six carloads of fat cattle, or 14 carloads of fat hogs, may contain phosphorus equivalent to that contained in the surface 6 inches of an acre, and the milk from a dairy of 130 average cows will carry off this quantity of phosphorus every year.

Thorne also makes the following significant statement:

> The ultimate function of agriculture is to feed and clothe humanity, and the most important element in human food is phosphorus. Under existing conditions the greater part of the phosphorus consumed by mankind eventually finds its way to the sea or to the cemetery, so that there is a steady flow of this element from the soil which is never returned. Wherever, therefore, the land has been under cultivation for any considerable length of time there will be a deficiency of phosphorus, except in the rare instances in which the soil has been naturally stocked with an abnormal supply of this element.

SOME RELATIONSHIPS OF SOIL TO PLANT AND ANIMAL NUTRITION—THE MAJOR ELEMENTS[4]

C. A. Browne, Supervisor of Chemical Research
Bureau of Chemistry and Soils

It is to the primeval lithosphere, or rocky surface of the globe, that plants, animals, and man owe the ultimate origin of the dozen or more mineral elements that are necessary for their existence. Yet a comparison of the relationships between the mineral elements of the lithosphere and those in food plants and the body of man shows a great disparity. This is indicated in Table 6, which has been calculated from the averages of various compilations. While the averages given in this table would be changed somewhat by the incorporation of other analyses of the mineral matter of rocks, soils, plants,

[4] From "Soils and Men," Yearbook of Agriculture, 1938.

and human beings, the figures given are sufficiently accurate to illustrate the general trend of elementary transmigrations.

The plant is the great intermediary by which certain elements of the rocks, after their conversion into soil, are assimilated and made available for the vital processes of animals and man. The simple inorganic constituents of the atmosphere and soil are selected and built up by the plant into protein, sugar, starch, fat, organic salts, and other substances of marvelous complexity. The substances thus synthesized by the plant are subsequently elaborated, with additional selections and removals of elementary components, by the vital processes of the animal body into flesh, blood, bones, and other structural materials. To investigate the progressive steps of these transfor-

TABLE 6

Approximate Percentages of Elements (Excluding Oxygen) in the Mineral Matter of Rocks, Soils, Food Plants, and Man

Element	Igneous and Sedimentary Rocks *	Soils †	Food Plants ‡	Human Body §
	(Percentage)	(Percentage)	(Percentage)	(Percentage)
Silicon	51.96	71.63	2.05	
Aluminum	15.14	13.74	(5)	
Iron	9.48	6.86	1.58	0.13
Calcium	6.85	1.02	8.44	42.24
Potassium	4.84	3.02	52.85	8.34
Sodium	5.16	1.08	5.56	6.03
Magnesium	3.90	0.68	6.06	1.32
Titanium	1.16	1.06	(5)	
Phosphorus	0.25	0.12	16.77	23.85
Manganese	0.17	0.12	(5)	(5)
Sulphur	0.10	0.10	3.03	13.14
Barium	0.09	0.17	(5)	
Chlorine	0.08	0.07	3.50	4.84
Chromium	0.07	0.01	(5)	
Fluorine	0.05	0.06	(5)	0.06
Undetermined (zinc, copper, iodine, cobalt, boron, etc.)	0.71	0.26	0.16	0.05
Total	100.00	100.00	100.00	100.00

* Compilation of many analyses by Clarke and Washington (66).

† 26 analyses of various soils by Robinson (313).

‡ 20 analyses of common food plants, Wolff's Aschenanalysen (471).

§ Average of 2 compilations, by Sherman (356) and Bertrand (33, p. 53).

Note: Numbers in parentheses refer to Literature Cited, p. 1181, "Soils and Men," Yearbook of Agriculture, 1938.

mations of matter by plant and animal life and to make them conform so far as possible to man's special requirements are the chief aims of agricultural science.

A comparison of the average elementary composition of the mineral matter of soils and of food plants, as given in Table 6, shows several marked differences. Plants possess a very evident faculty of assimilating certain elements, as calcium, potassium, magnesium, phosphorus, and sulphur, in much greater quantities than their abundance in the soil might lead us to suppose, and of more or less effectively rejecting other elements such as aluminum, the second most abundant mineral constituent of soils. If the comparison be extended further to the constituents of the human body, it will be noted (Table 1) that the animal organism has selective faculties of further segregating the mineral elements that have been assimilated from the soil by food plants. Thus the ratios of calcium in the mineral elements of soils, plants, and man, in the examples cited, are approximately 1 : 8 : 40, those of phosphorus 1 : 140 : 200 and those of sulphur 1 : 30 : 130, respectively. Attention is again called to the fact that these ratios are not absolute but only indicative of trends. It is significant that silicon and aluminum, the two most abundant mineral elements of the earth's crust, are found only in traces in the bodies of men and animals.

Of the mineral elements whose percentages are listed in column 4 of Table 6, only six (iron, calcium, potassium, magnesium, phosphorus, and sulphur) are commonly regarded as essential to plant life. These six mineral elements are also essential to the life of men and animals, who require also for their physiological processes the additional elements sodium and chlorine, which they obtain chiefly in the form of common salt.

In addition to the 15 mineral elements listed in Table 6, there are over 30 others which have been found in soil in minute traces; many of these so-called "trace" elements have been detected also in the mineral matter of plants and animals. In recent years it has been found that of these trace elements manganese, zinc, copper, and boron are essential for the proper development of certain forms of plant life. Similarly, in the case of animals and man, traces of iodine are necessary for normal development, although this element does not appear to be necessary for plants.

FAUNA AND FLORA OF THE SOIL [5]

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and
Nathan R. Smith, Senior Bacteriologist
Division of Soil Microbiology, Bureau of Plant Industry

Rocks, minerals, and elementary substances on the surface of the earth have been subjected to the corrosive power of the carbon dioxide of respiration and fermentation, to acids produced during the decomposition of suc-

[5] From "Soils and Men," Yearbook of Agriculture, 1938.

cessive crops of plant material and to enzymes secreted by micro-organisms. The soil as we have it today is the cumulative result of ages of such attack, combined with the physical effects of weathering. Few substances added to the soil escape this solvent action. Among examples, metallic sulphur passes over into sulphide and sulphate[6]; iron scatters in several directions; arsenic, selenium, and tellurium in contact with micro-organisms are transformed into vile-smelling gases. The sands of desert areas, where the absence of water makes micro-organic life impossible, represent soil materials without the presence of life which would transform them into soil. There is no true soil without organic matter, which may be classified as it exists in the soil into living and dead forms.

Various Kinds of Bacteria

In the breakdown of organic matter, most of the carbon dioxide escapes from the soil into the air. The ammonia, on the other hand, is actively absorbed by the soil, and usually very little is lost. The odor of ammonia, normally associated with a decomposing pile of manure or grass clippings, disappears when a thin layer of soil is spread over the heap because the soil absorbs the ammonia and at the same time acts as a blanket to keep out oxygen, thus slowing up the rate of decomposition.

Ammonia absorbed by the soil is rapidly changed to nitrite and this to nitrate by nitrifying bacteria, which seem to be most active in the absence of organic matter, particularly in the laboratory, where they are very difficult to grow in pure cultures. Crude cultures of certain nitrite bacteria can be obtained by trickling a mineral solution containing ammonia through a tower filled with broken limestone which has a little soil scattered over the top. The use of a nitrite solution instead of ammonia will give a good development of the nitrate bacteria.

There are a number of forms of free-living bacteria that can fix nitrogen, several of which are widely distributed. Of these, Beijerinck described *Azotobacter* from soil in 1901 as a genus of micro-organisms that can use the nitrogen of the air in building up proteins within their bodies and thus by continued growth and death can increase the nitrogen content of the soil. This fixation of nitrogen can take place only in a neutral or alkaline soil. Acidity (pH values less than 6.0) apparently paralyzes the mechanism of nitrogen fixation. The bacteria, however, can remain alive in a soil more acid than pH 6.0, even though they fix no nitrogen.

Worms and Burrowing Animals

Worms varying in size from great earthworms to forms scarcely visible to the naked eye are represented in the fauna of most soils. The smaller forms are seen mostly near the surface in the A horizon. The well-known earth-

[6] For a review of the literature on this and most of the other subjects mentioned in this article, the reader is referred to Waksman (445), "Soils and Men," *op. cit.*

worms feed at or near the surface upon plant remains, which are ingested or dragged into their burrows. These species are so dependent upon moisture, however, that they must encyst or withdraw into the deeper layers of the soil in dry weather to keep their bodies moist. Since they drown in water, the larger species are found inhabiting permanent burrows, often running vertically several feet, which make possible a safe balance between air and moisture requirements. Large amounts of earth are ingested with their food and pass through their alimentary canals. Their casts, which consist of earthy matter bound together with the humidified residues of food eaten, furnish a suitable environment for many micro-organisms. Marbut expressed the belief that in certain areas the granular condition characterizing whole layers of soil was due to earthworm casts. Certain mulls, or granular mixtures of mineral and organic material produced by earthworms, give particular areas of the forest floor their whole character.

Balanced Microbial Populations

In virgin soil or in areas in which natural competition has been undisturbed for long periods, the micro-organisms and green plants are found to reach a fairly stable balance. The swamp, the forest, the prairie change their aspects slowly over long periods. When farming operations are introduced, this balance is destroyed. Whole sections of the organic population are wiped out, and new alignments are started. Plowing and cultivating increase the activities of the micro-organisms, and the accumulated organic remains that made the freshly broken prairie so fertile are broken down at a greatly accelerated rate. In many areas no adequate steps have been taken to replace what has been destroyed. Micro-organic activities in the soil are desirable when they serve man's purpose; they become undesirable when they are stimulated to the point where they destroy fertility faster than it can be replaced.

LIMING, FERTILIZING, AND MANURING

The continued and effective production of crops varies with the selection of crops and the planting of rotations that will prevent excessive losses from soil erosion and that will maintain or increase the content of organic matter and nitrogen in the soil. Lime and fertilizers must be applied where needed to the right crops at a time when they can be most effectively and cheaply applied. As a general rule, large yields per acre produce the most profit and the best quality of crop products. Such yields can be secured only on fertile soils under a system of crop rotation and fertilization that provides for fertility upkeep. Under conditions where poor drainage is a cause of low yields, the land must be drained effectively by the use of tile drains

and adequate ditches in order to make soil-improving practices effective.

Organic matter is considered foundational to soil fertility and improvement. Through the decomposition of humus in the soil, the mineral elements of soil particles are made available to plants. Bacterial life is effective in aiding nitrogen and in rock decomposition, increasing the content of organic matter and its reduction through chemical and bacteriological action to form humus. The aeration of the soil and the reduction of capillary movement of soil moisture are beneficially affected by the increased content of organic matter.

The growing of cover crops, particularly green-manuring crops and legumes, and the application of manure are the means employed to increase and improve the contents of organic matter. The mineral elements most likely to be deficient in our soils are calcium, phosphorus, and potash. In the humid areas of the United States, where leaching and erosion are greatest, calcium and phosphorus may be deficient even in virgin soils. The removal of crops over a period of years draws heavily upon these elements. The use of lime is essential for correcting acidity so that leguminous crops can be grown and so that applications of phosphorus where needed may prove effective. It is now recognized that the qualities of grasses, hay, and other feeds depend upon the existence in the soil or applications to the soil of lime and fertilizers, and the vitamin content of feed crops and the content of calcium and phosphorus require the presence of these elements in the soil. Field crops and vegetables consumed by livestock and human beings are much more efficient in maintaining health when grown on soils adequately supplied with fertility.

Six mineral elements are recognized as essential to plant life. They are iron, calcium, potassium, magnesium, phosphorus, and sulphur. Recently it has been found that traces of minor elements, such as manganese, zinc, copper, and boron, are necessary to the proper development of certain forms of plants.

In areas of known deficiency, these elements are being constantly included in commercial fertilizers, as stated by Mr. Gove Hambidge,[7]

> What the soil does not have plants will not get and animals and man will lack also. The welfare of man is ultimately bound up with the welfare of our soils and plants because all of our food comes in the first instance from plants.

[7] Judd and Detwiler, "Hunger Signs in Crops."

Applying Lime

Calcium carbonate or calcium and magnesium carbonate or lime, as it is commonly called, is very soluble and leaches rapidly from surplus soils under cultivation. Soils of humid regions generally become acid or deficient in lime after several generations of cropping. The soils of the humid areas of the United States, particularly light loams and sandy soils, are naturally deficient in lime. Acid soils are

Fig. 22. Spreading ground limestone is an essential practice on most farms in the eastern half of the United States.

generally indicated by the presence of sorrel, broomsedge, and docks and by the absence or poor growth of clover, sweet clover, and other legumes. Soils easily may be examined to ascertain the lime needs by such tests as the Teskit, Richorpoor, Soiltex, or Truog. Initial applications of 2 or more tons of ground limestone per acre usually will correct soil acidity and make possible the growing of good crops of clover, alfalfa, and other legumes.

Good sods of bluegrass can be secured only on soil well supplied with calcium. Since the grasses and legumes are basic in the feeding of livestock, the application of lime, to correct acidity, and the use of lime in rotation are essential to successful crop and livestock production. Ground limestone, hydrated lime, or other forms of lime can be applied generally by the use of a lime spreader when preparing a seed bed for corn or other cultivated crops or as a top dressing on

sod lands before they are plowed under. Hydrated lime is used when it is necessary to make a long haul from the nearest shipping center. From 1500 to 2500 pounds per acre are generally needed.

During recent years, as a result of the awarding of lime applications in connection with the Agricultural Conservation program, ground limestone has been made generally available and, by the practices, the use of lime has been increased more than 300 per cent during the past five years.

Applying Fertilizers

The methods of applying fertilizer and the amounts used depend upon the needs of the soils and also upon the needs of the crop grown. It is now possible to have soils properly tested, usually through co-operation with the county agent, in order to determine the needs for phosphorus, and potassium, and lime. Fertilizers may be applied when planting small grains or drilling corn or planting potatoes. For hill crops, such as potatoes, beans, and corn, it is most effective to use fertilizer attachments or drills that place the fertilizer several inches away from the seed or plant, near enough to be used quickly but not near enough to damage the plant. Pasture and meadow crops are generally fertilized by broadcasting or top dressing with a fertilizer drill. The amounts recommended by the state agricultural experiment stations vary from 200 to 400 pounds per acre of complete fertilizers on corn, small grains, pastures, and meadows to as high as 1000 or more pounds for truck crops, potatoes, and tobacco, in accordance with the fertility of the soil. On soils well supplied with calcium, organic matter, and potassium, superphosphate is used effectively for corn and small grains or as a meadow top dressing at rates of 150 to 400 pounds per acre.

Applying Barnyard or Stable Manure

Manure from livestock has long been recognized as one of the most valuable sources of plant food. The average ton of livestock manure contains 10 pounds of nitrogen, 5 pounds of phosphoric acid, and 10 pounds of potash, and is worth $2.00 to $3.00 per ton. Losses of nitrogen occur when manure is allowed to ferment or heat, and excessive losses of fertility occur when the manure is allowed to remain in feedyards, unprotected from the rain. Whenever possible, manure should be applied to the land as rapidly as it is produced. The use of plenty of bedding or litter to soak up liquid manure is essential

in preventing great losses in the stable or feedlot. Dairymen have found the use of superphosphate, scattered on floors and in gutters, effective in preventing manure losses. Usually 30 pounds of superphosphate is used per ton of manure in the barn or stable. Since manure is rather low in phosphate as compared to its nitrogen-potash content, this reenforcement of phosphate application improves its value.

Under conditions where manure cannot be hauled to the field as produced, it should be stored under cover to keep rains from washing it. Tight floors should be provided to prevent draining away of liquid manure. Feeding livestock in covered feedyards or using ample straw or other bedding is an effective way to handle manure. Trampling of the livestock will pack it tight, thus reducing fermentation. Manure is handled most effectively under systems of livestock management that provide for the pasturing off of cattle, hogs, or sheep on corn, small-grain, or pasture crops.

CHAPTER VII

SOIL CONSERVATION—PLOWING, FITTING, AND CULTIVATING THE SOIL

Efficient crop production requires that seed beds be prepared properly and that plowing, fitting, and cultivating be performed with the effective implements that reduce production costs. As compared to land that is covered by grass sods or close-growing plants, land that

FIG. 23. Contour strip cropping on a slope of 23 per cent. The strips are 60 feet wide with the top of each strip exactly on the contour. The rotation system is corn and wheat and alfalfa (four years). (*U.S.D.A.*)

is plowed or planted to intertilled crops provides conditions that result in much greater erosion losses from water and wind. It is imperative, therefore, if we are to use our land properly and not abuse it, that attention be given to practices that reduce erosion losses when the land is plowed or planted with cultivated crops or left bare. The program to prevent soil losses includes such practices as plowing and fitting land along the slopes, rather than up and down with the slopes, contour furrowing, strip cropping, listing, terracing, gully fill-

ing, the grassing of waterways, constructing percolators and water spreaders.

The proper planning of rotations so that plowing may be necessary only once in three- to five-year periods is effective in reducing costs and strengthening the soil-conservation program. In standard rotations the soil is plowed and fitted for cultivated crops such as corn, cotton, potatoes, beans, or beets the first year. These crops are followed in the fall or spring with plantings of wheat, oats, barley, or rye, the soil being fitted by discing or harrowing. The small-grain crops are seeded with companion crops of legumes and grasses, generally planted in early spring, which occupy the land the second year without tillage. During the third year a legume-and-grass hay crop occupies the land and may be continued for hay and pasture purposes during the fourth year and following.

The purposes of tillage are defined by John S. Cole and O. R. Mathews in the United States Department of Agriculture Yearbook for 1938, as follows:

> Three primary objectives dependent on time and place may be recognized as the fundamental purposes of tillage: (1) To prepare a suitable seedbed; (2) to eliminate competing weed growth; and (3) to improve the physical condition of the soil.

In addition to these major purposes, tillage is highly effective in controlling insects and certain plant diseases.

A GOOD SEED BED

The seed bed must be prepared so that the best possible conditions are provided for the germination of seed planted and the subsequent growth of plants. Good seed beds should be finely pulverized and sufficiently compact so that capillary moisture will come in contact with the seed, but loose enough to permit air to penetrate into the soil to supply oxygen for the germinating seed and the growing plant. The surface of the seed bed should be free of growing weeds or other plants and of crop residues, except in areas of extreme erosion where the leaving of clods and crop residues may be advisable. Good plowing, followed by thorough fitting of the seed bed to control weed growth will greatly lessen the cost of weed control by later operations. Additional working of the seed bed before planting the crop will greatly reduce the number of later cultivations.

PLOWING

The time of plowing depends upon many factors: whether the ground is open or frozen, the amount of moisture in the soil, the time of planting the crop, the weeds, insects, or plant diseases that are to be controlled. Plowing when the soil is either too wet or too dry may result in lumpy seed beds that are hard to reduce to a good condition of tilth. Heavy clay soils are more exacting in requiring that

FIG. 24. Turning under a green-manure crop of crimson clover in preparation for potatoes. (*U.S.D.A.*)

moisture conditions be just right than are sandy soils that have a greater range of time in which they can be plowed without injury. An old rule is that soil is in condition to plow when it will mold in the hand but falls apart when tapped lightly with the finger. In humid regions where rains are frequent, plowing should be deferred until spring in order to keep the ground covered with vegetation, thus preventing erosion losses. In dry regions it may be necessary to plow the land before winter and keep the soil open by cultivation in order to store the rain that comes.

In preparing the land for corn, potatoes, beans, cotton, and other cultivated crops, it has been found by practice and experiments that most soils give best results when plowed to an approximate depth of 7 inches. Pasture sods, clover, alfalfa, and lespedeza are usually turned under, to be followed by the cultivated crops. Under condi-

tions where land is level and erosion losses and losses by leaching are not likely to be great, fall or winter plowing may give best results, since ample time is offered for the decomposition of plant residues and manure turned under. Fall plowing is generally employed in the Corn Belt and Northern States. In Southern States, where rainfall, and hence erosion and leaching, are greatest, use is made of cover crops that grow during the winter, and plowing in the spring is the general practice. Soils that tend to pack, such as heavy clay lands, are not benefited by early fall plowing. Spring plowing is much more generally employed than fall plowing. Plowing should be done early enough in the spring to provide time in which to prepare a thoroughly settled and properly conditioned seed bed before planting. It is usual to use the cultipacker or roller immediately after plowing and the disc, spring-tooth or spike-tooth harrow at intervals of a week or ten days until the crop is planted. The seed of corn, beans, potatoes, and sugar beets starts best on seed beds plowed to a good depth, with the lower part of the furrow slice thoroughly settled and the surface in a fine condition of tilth.

CONTROLLING WEEDS, INSECTS, AND PLANT DISEASES BY EFFECTIVE TILLAGE

Weeds are most effectively controlled by rapid and thorough fittings of the seed bed before the crop is planted. Much greater acreage can be covered in a day with a disc, spike-tooth, or spring-tooth harrow than with a cultivator used after planting. Weeds are most effectively controlled by cultivating when weed seeds are germinating or the weed plants are small.

The Hessian fly, which may cause great damage to wheat and to winter barley, is controlled by plowing under infested stubble as soon after harvest as possible and by fitting the seed beds for planting at fly-free dates in the fall. The European corn borer is controlled by turning under infested corn stalks or stubble to a good depth before May 1, and by removing and destroying all remains of infested corn stalks from the surface of the soil. Grasshoppers are controlled by fall or early spring plowing to a good depth to expose the egg masses (which are generally within the first 3 inches of soil) to the effects of drying or freezing.

The scab or other fungus diseases that affect small grains are carried over in the stubble that is left after the crop has been harvested. By plowing small grain stubblefields as soon as possible after harvesting, losses from these diseases in the small-grain crops are reduced.

Fig. 25. Fitting land for cotton in Mississippi. Cultipackers follow middle-busters which turned under bur clover.

Fig. 26. Water standing in lister ridges in a strip-cropped Oklahoma field after a heavy downpour. Listing with the contour prevents erosion and conserves water.

SPECIAL TILLAGE PRACTICES THAT CONSERVE THE SOIL

Contour Farming

In "Soil Defense in the Northeast," Mr. Glenn K. Rule of the Soil Conservation Service, states the following in regard to the need of farming on the contour.

Our inherited rectangular system of farm lay-out of land has enforced field arrangements that are inappropriate for a rolling countryside. It has been said that this system "tried to fit square farming to a round country." As a consequence many farms lie in a long narrow strip leading from a valley up the grade to a plateau at the crest of the hill. To aggravate this situation these farms have frequently been subdivided lengthwise in several fields. Farming these long fields up and down the slope has been a direct cause of severe soil loss.

There are a number of obvious reasons why fields should have been laid out on the contour or across the slope. Plow furrows around the slope make a series of soil dams that hold water on the field, giving it more time to soak in rather than run off; harrow teeth leave smaller but more of these obstructions, and cultivator teeth leave similar grooves on the soil devoted to row crops during the growing season. Since grass seedings or mixtures of grass seedings are usually made as the grain is being drilled, or soon after, much of this seed falls into or is washed into the drill furrows. Consequently, both the plants of the nurse crop and the grass plants emerge in contour lines. The resulting rows of grass on the contour more effectively check the flow of water than they would if they ran up and down the slope.

Farmers who have tried contour farming report field work to be much easier on man and team because all machinery is drawn on the level. Present evidence indicates that much less power is required to farm on the contour than going up and down the slope.

Strip Cropping

During recent years the practice of planting crops in strips on sloping lands in the humid eastern half of the United States has come into general use largely as a result of the demonstrations of the Soil Conservation Service and the practice awards of the Agricultural Adjustment Administration program. Intertilled crops are alternated with grass, legumes, or small grains in long, narrow strips that follow the contours of the slope. During rains, rapid run-off of water is checked by these growing strips of grasses or legumes and a large part of the soil carried in the run-off is deposited. The width of the strips

depends largely on the degree of the slope. They usually vary 50 to 125 feet.

Under western conditions, where wind erosion may cause great damage, strip cropping is found effective in reducing erosion losses. Planting with sorghum or corn in strips, with hay crops or other crops

FIG. 27. Storing water for future crop use on a South Dakota farm. Little puddles, provided by a basin-type listing machine, hold water until it sinks into the soil and retards erosion. (*Soil Conservation Service, U.S.D.A.*)

alternating, greatly reduces the sweeping of the wind and the amount of surface soil carried away.

Another advantage of strip cropping is that there is very little uphill and downhill driving in seedbed preparations, planting, and cultivating. The cost of these operations is reduced by following the contours, and the danger of rapid formation of gullies is greatly lessened.

Terracing

Terracing is a system of preparing broad ridges of soil across the slope of the land, following the contour so that surface water may be carried away along a slight grade leading to a properly protected outlet. The distance between the ridges depends upon the slope.

Experiments of the Soil Conservation Service resulted in the preparation of Table 7 as a general guide.

TABLE 7 *

TERRACE SPACINGS ON LAND OF DIFFERENT SLOPES

Item	Terrace Spacing on Slopes per 100 Feet of —				
	2 feet	4 feet	6 feet	8 feet	10 feet
	(Feet)	(Feet)	(Feet)	(Feet)	(Feet)
Vertical fall between terraces	$2\frac{3}{4}$	$3\frac{1}{2}$	4	$4\frac{3}{4}$	$5\frac{1}{2}$
Distance between terraces	137	88	67	59	55

* From Soil Defense in the Northeast, U.S.D.A., Farmers' Bul. 1810.

FALLOWING

In regions of scant rainfall, the land is frequently plowed and cultivated, or fallowed for one growing season in order to conserve moisture in sufficient degree to provide for a crop the following season. Proper fallowing consists in cultivating the soil frequently enough to prevent weed growth and to keep the surface of the soil covered with a loose layer of soil. By preventing plants from growing and by reducing evaporation and providing an absorptive surface to store rain when it comes, sufficient moisture is stored up in the soil for a crop during the second year. Where wind erosion is serious, it may be necessary to ridge the soil at intervals in order to reduce erosion losses.

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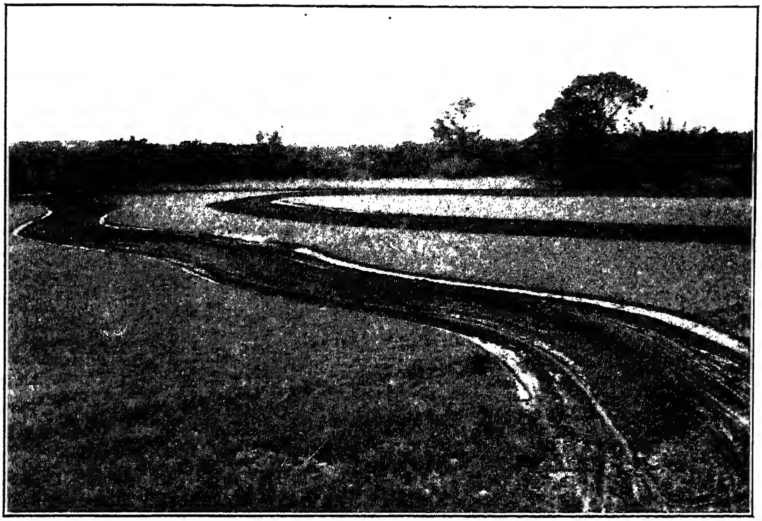

FIG. 28. Newly completed terraces in Oklahoma.

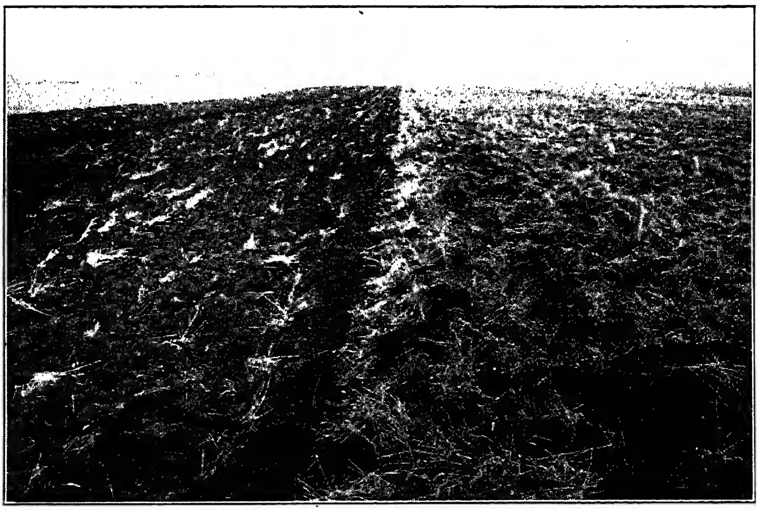

FIG. 29. Newly developed land-fitting machinery aids in preventing wind erosion. At left, plowed by moldboard plow; right, fitted with arcway disc tiller. (*U.S.D.A.*)

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CHAPTER VIII

COVER, GREEN-MANURING, AND SUPPLEMENTARY FEED CROPS

In order to supplement and maintain rotation programs, there is frequent need for emergency crops planted when the crops in the regular rotation fail, owing to adverse weather conditions or as a result of insect or disease injury. For this purpose crops that can be planted late in the season, which will produce an abundance of growth for forage purposes, are used. Buckwheat, sudan grass, soybeans, millet, rutabagas, and turnips—all can be planted as late as early July on land where a spring-seeded crop has failed. Green-manuring crops and cover crops are planted for the purpose of giving cover that will protect the soil from erosion and leaching and that will increase the content of organic matter in the soil when turned under or incorporated with the surface soil by discing in.

The leading summer green-manuring crops are soybeans and Hubam clover, adapted to the Corn Belt and western conditions; lespedeza for the southern Corn Belt and northern Cotton Belt; crotalaria and velvet beans, soybeans and cowpeas in the Cotton Belt. Kudzu is an important perennial crop in the South. In the Northern States buckwheat is sometimes grown on heavy clays for the purpose of lightening these recalcitrant soils. The growing of winter cover crops that protect soils from erosion and the leaching of fertility is highly important, particularly in Southern States where the ground does not freeze and is seldom covered with snow. Winter small grains, rye, wheat, oats and barley, and winter peas and winter vetch, or vetch and rye and bur clover, are the leading winter cover crops used in the Gulf States and the East Central States. Crimson clover is an important winter cover crop in East Central States and eastern truck-crop regions. Throughout the East Central States, wheat, rye, and winter barley, either seeded alone or with vetch or crimson clover, are commonly used for the purpose of plowing under in early spring and are followed by corn, tobacco, potatoes, or other cultivated crop.

Supplementary or emergency pasture and hay crops are needed frequently in order to maintain the necessary roughage supply. When bluegrass pastures fail during hot, dry periods of midsummer and

later, supplementary pasture crops are needed. During seasons when hay yields of the regular hay crops in rotation are lessened, emergency hay crops must be planted. It is sometimes found advisable to increase the livestock to the point where more pasture and hay are needed. In such cases, increased pasture and hay can be secured by

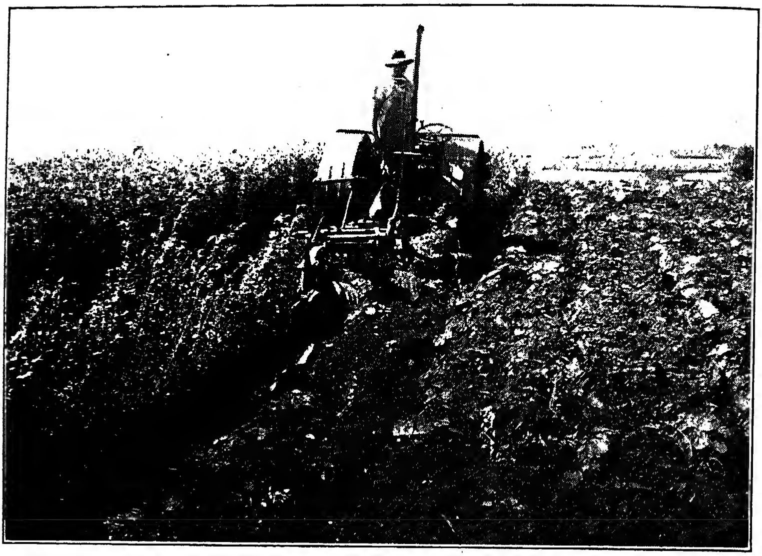

FIG. 30. Sweet clover grown to be turned under on the contracted acreage of the first AAA program. During the first three years of the AAA (1933 to 1935), more than 35,000,000 acres were shifted from corn, cotton, wheat, and tobacco to soil-conserving crops or were used in soil-conserving practices. Since 1936, direct payments of AAA awards have been made on specified soil-conserving practices and crops. (*U.S.D.A.*)

growing such crops as sudan grass, sorghum, or corn to be pastured off or cut for roughage purposes. Soybeans planted for hay purposes make an excellent crop to replace or supplement clover and alfalfa. The planting of turnips or rutabagas in late July or early August or at the time of the last cultivation of corn will furnish a very considerable amount of fall grazing or root crops for winter feeding.

RYE AND HAIRY VETCH

These crops planted together make a valuable soil-improving pasture, hay, and seed crop. Abruzzi rye is preferred throughout the South, and hairy or winter vetch gives better results than other

vetches over a widespread area. Common vetch is employed in regions near the Gulf of Mexico. It is usual to plant 1 bushel of rye and 20 pounds of vetch seed during early September in northern regions and during early October in the South. When planted with corn at the last cultivation, vetch and rye will produce excellent pasture for late winter and early spring use.

FIG. 31. Hairy vetch, seeded at last cultivation of corn, provides excellent winter cover. (*U.S.D.A.*)

For hay purposes crops should be cut when the vetch is in bloom, and for seed when the rye and vetch seeds are mature. Vetch and rye are recognized as a valuable cover crop for orchards. The plantings should be made in the late summer or early fall. The crop is turned under when good growth is developed in the spring. Rye and wheat seeded alone are often used for winter-cover purposes, but the inclusion of vetch increases the organic matter and nitrogen content of the soil and improves the forage. In many Southern States, vetch is frequently seeded alone, after cotton is laid by, in order to protect the soil and increase the nitrogen content for a crop to be planted the next spring.

WINTER PEAS

The use of winter peas as a winter-cover crop has increased very rapidly in Southeastern United States during the past few years. Seed production of winter peas has been encouraged by the Agricul-

tural Adjustment Administration in Oregon and other Northwestern States, and the use of the crop encouraged in the Southeast by grant-of-aid distribution of winter-pea seed in connection with the soil-conservation practices of the Agricultural Adjustment Administration program. This crop is generally planted in late September or early October. Inoculation is necessary when land is planted to Austrian peas for the first time. Winter peas are excellent nitrogen gatherers and develop a large amount of succulent roughage that is quickly incoporated with the soil when turned under in the spring.

PEAS AND OATS

Peas and oats are widely used for emergency hay and pasture purposes in Northern States. They are planted during April or early May, using 1 bushel of field peas and 1 or 1½ bushels of oats per acre. Peas and oats make an excellent crop for the silo, and yields as high as 10 tons per acre of pea and oat forage have been produced at the Michigan Upper Peninsula Substation. Inclusion of peas with oats increases the protein content of hay or ensilage and the amount of nitrogen contributed to the soil.

SUDAN GRASS

Sudan grass is one of the most reliable emergency hay, pasture, and cover crops. It is adapted for this purpose throughout the Corn Belt and Southern and Southwestern States. From 20 to 30 pounds of seed per acre is usually employed. Plantings may be made as late as early July. Sudan grass is generally considered superior to millet for pasture and hay purposes and has rapidly gained in use.

MILLET AND SORGHUM

Millet crops and sorghums may be used for roughage and ensilage purposes and will stand planting at a considerably later date than corn. For hay or fodder, sorghum is seeded with an ordinary grain drill at the rate of 40 pounds per acre and is cut for roughage purposes when the seeds are in dough stage, using an ordinary mower and curing in small cocks. Yields of 3 to 5 tons of roughage may be expected on good land. The Early amber sorghum is generally recognized as a superior roughage and silage variety, although many other varieties are used.

SOYBEANS

Soybeans may be planted in May or June, and for pasture and hay purposes as late as early July in the Corn Belt. When used for pasture and hay, 2 bushels of seed are generally planted, using a grain drill or broadcasting. The crop should be cut for hay when the pods are nearly filled and before the seed has become firm. After mowing,

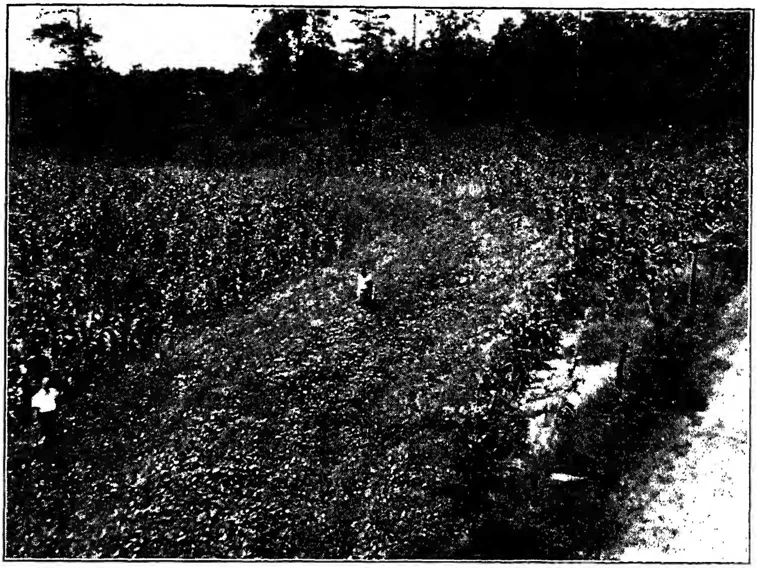

Fig. 32. Terraces must be protected by a close-growing crop. Cowpeas are widely used for this purpose in the Southern States. (*U.S.D.A.*)

the crop is cured in windrows, in small cocks, or in stacks along poles or steel fenceposts to insure curing. The viney varieties, such as Wilson and Ebony, are preferred for hay and pasture purposes, although practically all varieties may be employed for emergency use.

SMALL GRAINS FOR WINTER COVER

Small-grain crops collectively are by far the most widely grown of the winter-cover crops. Winter wheat and winter rye are generally adapted to northern and southern regions. Winter barley is of increasing importance in East Central and Central States, and both winter oats and winter barley are grown in Southern States. The growth of the small-grain crop during the fall, winter, and early

spring not only protects the soil from erosion but also prevents great losses from the leaching of nitrates and other elements of fertility, making these elements available to the following crops if the small-grain crop is turned under. Small grains grown during the winter

FIG. 33. This southern farmer uses crotalaria as a summer soil-building crop. (*U.S.D.A.*)

may be harvested for grain or used for pasture and hay, or plowed under in the spring to increase the organic matter in the soil. Rye-grass is also being grown for winter cover and for pasture purposes. During seasons of fall drought, it is particularly important that winter-cover crops be planted in spite of the difficulty in preparing soils. Nitrification goes on during the drought, and losses from leaching and crop removal are at a minimum. By providing a growing cover crop, many pounds per acre of nitrates can be built into plant tissues and much loss by leaching and erosion prevented.

CHAPTER IX

MANAGING PASTURES AND MEADOWS

In introducing the much-called-for Pasture Handbook of the United States Department of Agriculture to American readers, Secretary of Agriculture Henry A. Wallace said that he "suspected that we were going to revise our thinking about pastures" and suggested that "each farmer should examine for himself the possibility of devoting more of his land to pasture and meadow crops." Many farmers thus will be able to reduce production costs and thereby increase the net gains from their farms and improve their soil-fertility programs.

Grass has been given an important place in the Agricultural Conservation Program. Land that will not be needed to meet market demands for wheat, corn, cotton, and tobacco can be used largely for seeding to adapted grasses and legumes. These crops conserve and improve the land and retard the water run-off, thus protecting our watersheds and improving our streams. Since commencing in 1936, awards have been paid to farmers who cooperated in the Agricultural Conservation Program by planting new seedings of grasses and legumes on approximately 30,000,000 acres each year. Thus the farmers are aiding materially in balancing farm production and in placing our great agricultural industry on a better footing to meet future demands for crops for food and clothing in times of peace or war.

We look to grass to hold down our depleted rangelands and to heal the ravages of the recent droughts and floods. Warnings of the misuse of our land on a grand scale were recently broadcasted to the nation in the roar of flood waters and by unprecedented dust storms. Perhaps the answer to the problem of how to restore our soils after years of misuse is borne in the whisper that can be heard on any June day when the air stirs gently over grasslands.

THE SHIFT TO GRASS IN OUR AGRICULTURAL CONSERVATION AND ADJUSTMENT PROGRAMS

Experiments conducted by the United States Department of Agriculture and the state experiment stations have shown a need for the

increased uses of grasses and legumes in rotations carefully planned to protect the soil. Such rotations, together with the shifting to permanent pasture of land that is not suited to cultivation, help to maintain and improve productivity and to reduce the cost of producing milk and meat.

Grass and legumes have a most important part in the "ever-normal granary system" which aims at continued and permanent abundance, because of the ability of these soil-conserving crops to maintain and improve soil fertility and to replace profitably a part of the acreage devoted to crops in surplus. When planted to grass, part of the land that once produced wheat, corn, and cotton will give a good account of itself by producing cheap pasture and hay for livestock of all kinds—though not as much meat and milk can be produced from this part of our acreage when devoted to grass as when these same acres are used to produce corn, small grains, and soybeans, leading sources of concentrated livestock feeds.

The functioning of our legume and grass acreage in the farm-production program may be compared with that interesting, whirling gadget, the "governor," that regulated the flow of steam power on the old-fashioned, steam threshing engines of the past generation. If the governor went out of kelter, the engine sped up, a stream of wheat shot from the separator spout faster than it could be bagged, and much good grain went to waste in the straw stack. Bedlam reigned among the threshing crew until the governor was fixed. We have had our period of ungoverned production of wheat, corn, and cotton, and look to the constructive adjustments of our rotations to include increased acreages of grasses and legumes to aid in adjusting our production to normal demands for crops for food and clothing. Should the future bring emergency needs and should greater production of these crops be necessary, the turning under of available sodlands will provide for the increased needs.

SHIFTING TO GRASS STABILIZES LIVESTOCK PRODUCTION

While grass and hay crops as a class will not produce as much feed as corn and grain on the same land, livestock can be fed on grass and hay, to the extent of a large part of their ration, at less than half of the cost of feeding concentrated grain feeds. For this reason, we can adjust our agriculture toward more grass and legumes to the advantage of the livestock industry and without fear of producing embarrassing surpluses or of unduly developing the dairy and livestock industry in new regions. The consumer benefits from the adjustment

by farmers, toward a greater acreage in grass and hay, by the improvement in quality and a higher vitamin and mineral content in meat and milk, resulting from increased use of improved pasture and hay in feeding livestock.

Livestock specialists of the Department of Agriculture state in United States Department of Agriculture Miscellaneous Publication 194, A Pasture Handbook, that, according to calculations based on census data, lands in harvested grain crops, as produced generally

FIG. 34. Dallis grass is important in improving Alabama pastures. (*Blackbelt Experiment Station.*)

on farms of the United States, supply fully 50 per cent more nutrients for livestock than similar land in pasture, but that pasture is produced and utilized at a much lower cost, particularly of labor.

In seven districts where studies were made by the United States Department of Agriculture concerning the requirements for the production of market milk, pasturage furnished nearly one-third of the total subsistence for the cows. On these same farms the pasture cost was only one-seventh of the total feed cost.

Records obtained on 478 Corn Belt farms which produce beef calves show that the breeding cows obtained practically their entire living from pasture for 200 days, and from roughage and concentrates for 165 days. The pastures which were furnishing a little more than half of this total subsistence were credited with only one-third of the feed bill.

A survey of typical farms in southern Indiana showed that those with half their farm area in pasture and half in crops made more

profit than those which devoted one-fourth to pasture and three-fourths to crops. Thirty-six per cent of the total feed for dairy herds on these Indiana farms was obtained from pasture which furnished nutrients at one-fourth the cost of nutrients in harvested feed.

Adaptation of Grasses and Legumes. On most farms it is usual to devote the poorer lands, rocky or poorly drained soils, or steep hillsides to permanent pastures. Recently, however, many farmers have found that their better soils can be made to pay adequate profits when planted to legumes and grasses for pasture and meadow purposes. Standard rotations include legumes and grasses for hay, soil improvement, and limited grazing. From the standpoint of soil improvement through charging the soil with organic matter and adding nitrogen, the inclusion of grass and legume mixtures or of legumes planted alone is essential in maintaining soil fertility.

This balancing of rotation is equally essential in balancing the livestock ration providing cattle, horses, and poultry with an adequate supply of pasturage and with cured hay or grass silage to feed with grain crops. The pasture and meadow crops are needed in protecting soils from erosion and in making best use throughout the season of farm labor. They are essential in any program in farming that includes livestock and are necessary in the maintenance of soil fertility. Cheapest gains from growing livestock are produced on pasture and the inclusion of well-cured hay in maximum amounts with grain reduces cost in the production of finished animals, or of milk.

The grasses and legumes that should be chosen and the right proportion of seed to use in mixtures depend most largely on soil and climatic conditions and upon the use to be made of the crop, whether it is to remain for several years or permanently for hay and pasture purposes or whether it is designed for use for one or two years in rotation. Kentucky bluegrass is the standard permanent pasture grass of the Corn Belt, Northern and New England States on lands that are well drained and sufficiently supplied with lime and phosphorus. Canada bluegrass is adapted to extremely northern conditions under less fertile and well-drained conditions. Redtop improves pastures under adverse conditions, particularly on poorly drained soils and also on less fertile soils inclined to drought. Orchard grass is valuable because of its earliness in the spring and because it furnishes pasture from midsummer on, when bluegrass fails.

Timothy is a standard grass for pasture and meadow purposes in the eastern half of the United States and in the Northwest, owing to

its great hardihood and cheapness of seed. It is valued for both pasture and hay purposes.

In the Southern States dallis grass, Bermuda grass, Johnson grass, along with redtop and timothy, constitute the leading meadow and pasture grass. During recent years dallis grass has gained particular favor, owing to its value as pasture and the comparative ease with

FIG. 35. The first season's growth of kudzu. This viny legume is being employed on a vast scale in the primary improvement of depleted and eroded soils and is being used to provide pasture in the Southeastern States. (*U.S.D.A.*)

which it can be controlled when it is desirable to use the land for cultivated crops. Both Johnson grass and Bermuda grass, though valuable for pasture purposes, are exceedingly persistent and difficult to control when the ground is plowed for cultivated crops.

Grasses seldom are seeded alone for pasture and meadow purposes, but are accompanied by the proper mixture of legume seed in the Corn Belt and Northern States. Red clover and alsike clover, either singly or mixed, are generally planted with mixtures of timothy and redtop. Brome grass and alfalfa mixtures have increased greatly in use in the central Corn Belt and Lake States. Red clover requires a well-drained soil adequately supplied with lime, whereas alsike will do better on wet lands and poorer soils. Where it is desirable to de-

velop permanent pastures, white clover or ladino should be included in seedings in the Corn Belt, Lake States, and New England. In the Ohio Valley and Southern States lespedeza has recently demonstrated its value for pasture and hay purposes, either seeded alone or in mixtures.

Under irrigated or humid conditions of the Western and Northwestern States, red, alsike, and sweet clover, ladino, and alfalfa are

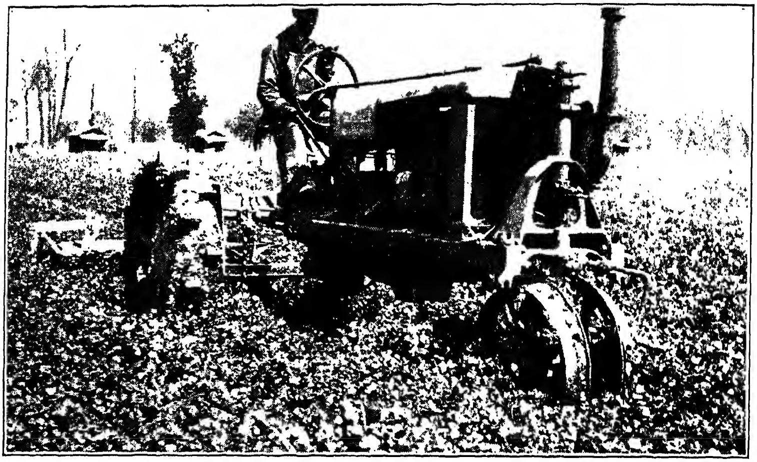

FIG. 36. Bur clover has become an important pasture and soil-building legume in the southern Gulf States.

recognized as the most valuable legumes to plant alone or with grasses. In the West and Northwest bromegrass and crested wheat grass, a comparatively recent importation from Russia, are of outstanding value in producing yields under conditions of extreme drought and low temperatures. In southern Texas, Rhodes grass, grama grass, and native buffalo grass are important.

Preparing the Soil and Seeding. The seed of grasses and legumes for pasture and meadow crops is exceedingly small and hence must be planted on thoroughly prepared, firmly packed, and smoothly surfaced seed beds at depths that barely cover the seed. If planted with a grain drill, accompanying small grains, the grass and clover seed should not be allowed to go through the drills with grain at depths of 1 inch or more, but should be distributed on the surface ahead of the drills through grass-seeder attachments. On winter wheat or rye, the grass and legume seed should be planted by using

a wheelbarrow seeder or rotary distributor during the winter or early spring when the ground is still honeycombed with frost. If planted in the spring after freezing, the seeding should be drilled or, if broadcasted, should be harrowed into the soil.

Fertilization. In the humid areas of the eastern half of the United States and the Mississippi Valley, liming of acid soils and applications of acid phosphate or, under certain conditions, of complete fertilizer are necessary. In preparation for successful pasture and meadow crops, the general rule, that 1 to 2 tons of ground limestone and 200 or 300 pounds of acid phosphate or complete fertilizer should be applied when fitting the seed bed, is advisable. Dressings of manure at the rate of 6 or more tons to the acre, applied when fitting the seed bed or as top dressings after seeding, are most effective, particularly when used in connection with lime and mineral fertilizers.

Controlling Early Weed Growth. As a general rule, pasture and meadow seedings are made on wheat or rye or with oats and barley as companion crops. Reduced seedings per acre and the early harvest of these crops will greatly improve the growth of grasses and legumes seeded with them. After the harvest of the grain crop, it is generally advisable to clip the legume and grass crop in early fall with mower bars set high in order to control weed growth. It is best not to pasture a new seeding of grasses and legumes during the first season, but, if it is necessary to pasture the crop, pasturing should be done late in the fall and for not too long a period.

Harvesting and Storing Hay. It is important that hay crops of timothy, orchard grass, redtop, bromegrass, ryegrass, and mixtures of these grasses, including clovers, should be cut for hay or for grass silage before they are too ripe. Palatability and protein and vitamin content are highest when the crop is cut in the bloom stage before seed begins to ripen. Red clover should be cut when the heads are just beginning to turn brown; alfalfa when one-tenth to one-quarter is in bloom; lespedeza while in early bloom. The use of left-hand side-delivery rakes that pile the hay in high, loose windrows is most effective in curing, since the leaves of legumes are best retained. Such windrows are easily turned if rained upon and are most easily taken up with modern hay rakes and hay loaders. Hay of any kind, legume, or grass is considered in condition for the storage stack or mow when a bunch can be twisted between the hands without showing moisture. If the crop is to go into the silo it can be hauled di-

rectly from the field to the chopper while in a green or wilted condition.

Feeding—Pasture and Meadow Crops. It has been well established by the experience of farmers and the experiments of agricultural experiment stations that good pasture furnishes the cheapest and most efficient feed for dairy cows, cattle and sheep, work horses and mules. Good pasture is also exceedingly valuable as a range for growing pigs and poultry. Labor costs are greatly reduced since animals on pasture do their own harvesting and spread their own manure. It is recognized also that the health of animals is improved during periods of feeding on good pasture, owing to exposure to sunlight, the increased vitamins, and the available nutrients that good pasture provides. Such diseases as Bang's disease and tuberculosis are reduced by pasturing herds, from which reactors have been removed, on clean pastures.

Costs of meat and milk can be reduced materially by feeding increased amounts of well-cured leguminous and grass hay crops, cut at the right stage of maturity. The health of animals and the quality of meat and milk are materially improved by the proper use of pasture and roughage crops in the feeding program.

PRACTICES IN SWINE FEEDING[1]

Pastures

Pasture crops are important in the economical production of hogs. They not only reduce the cost of needed protein, minerals, and vitamins but are a big factor in controlling parasitic infestation if a system of pasture-lot rotation is used. Pigs cannot be grown and fattened economically on forage crops alone, but these crops are an important adjunct to a good grain ration. The saving in the number of pounds of grain required to produce 100 pounds of grain when pigs are on pasture varies considerably. It is estimated that on the average good-quality pasture saves approximately 15 per cent of the grain concentrate per unit of grain and speeds up the rate of grain in comparison with hogs fed in dry lot.

Permanent pastures do not give the most economical returns unless they are supplemented by temporary pastures. A combination of the two is a valuable asset. When properly planned they can supplement each other and furnish good-quality grazing at practically all seasons of the year.

The plants used most extensively for permanent hog pastures are alfalfa, red clover, alsike, white clover, bluegrass, orchard grass, lespedeza, and car-

[1] From "Food and Life," Yearbook of Agriculture, 1939.

pet grass. The most common temporary-pasture plants are rape, rye, oats, wheat, soybeans, cowpeas, and field peas. Seeding for temporary pastures should be timed to furnish grazing for short intervals when permanent pastures are in a dormant or resting state. When given a period of rest after close grazing, temporary pastures may make sufficient regrowth to furnish a second grazing period before the field is plowed for the next crop. The rate of seeding for temporary pastures is usually much heavier than for a grain crop.

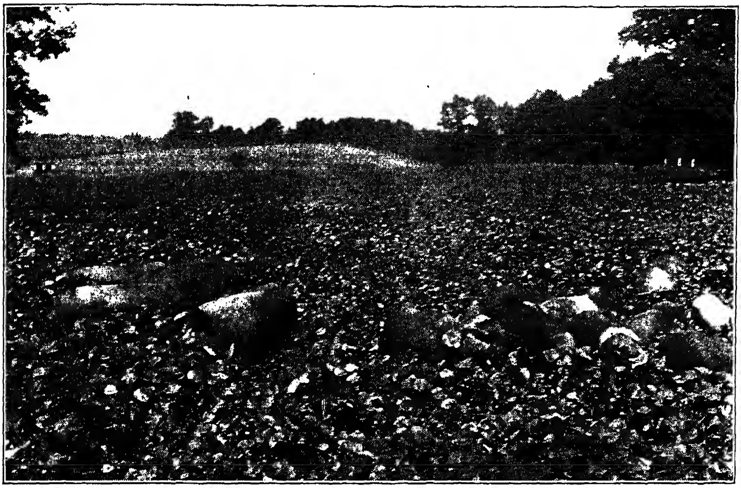

FIG. 37. Hogs foraging on soybeans and cowpeas at the Beltsville, Maryland, Experiment Station of the United States Department of Agriculture.

Legume crops such as alfalfa, the clovers, and rape usually yield the greatest returns in pork production. As a general rule pigs grazed on a good legume pasture when on full feed require approximately half as much concentrated protein supplement as pigs in dry lot. If the amount of the grain on pasture is limited, the pigs will consume a greater quantity of forage and possibly require only 30 to 40 per cent as much concentrated protein supplement as hogs in dry lot. As the hog grows it will be able to consume greater amounts of forage, thus progressively decreasing the amount of protein supplements needed.

Since there are so many different factors to consider in planning a pasture crop-rotation system for hogs it is best to consult the State agricultural experiment station as to the pasture crops best adapted to a particular region, the time and rate of seeding, and the stage of growth at which the crop should be pastured.

FEEDING OF DAIRY COWS[2]

Some Unfortunate Results of the Discovery of Dietary Deficiencies

. . . . By certain groups who wish to sell mineral mixtures, however, it is represented that farm animals everywhere suffer from calcium and phosphorus deficiencies—indeed, that most of the ills from which they suffer are due to such deficiencies. To cure these numerous ills it is represented that the mineral mixture put out by such and such a firm is especially potent. As a matter of fact, the tests that have been made with such preparations are usually very scanty and inadequate. In particular, it has turned out that calcium and phosphorus mixtures have frequently been made from rock phosphate, which is a cheap source of calcium phosphate. Rock phosphate usually contains fluorine, an element that is poisonous in the quantities in which it is contained in the rock phosphate. It takes some weeks or months, however, for its poisonous effects to make themselves manifest, and certain rock-phosphate preparations put on the market as supplements for cattle feeds have had disastrous effects on the health of cattle when fed for any length of time.

This is not the only known example of poisonous preparations being put on the market and widely advertised as beneficial supplements to feeds. Soon after the importance of vitamin A in the rations of dairy cattle was discovered, it was widely advertised that cod-liver oil or some preparation made therefrom should be added generally to the rations of farm animals. But it has been known for some time that cod-liver oil reduces the fat in the milk of dairy cows, and it has more recently become clear that, although cattle tolerate this drug fairly well, other animals such as sheep, goats, rabbits, and guinea pigs are readily poisoned by quite small doses of it.

It should be emphasized, therefore, that when animals are fed on the proper natural rations, mineral and vitamin supplements are unnecessary, and that it is not safe to assume that such preparations are harmless. The price the farmer gets for his products ought to be adjusted to make the feeding of good natural rations economically possible, for it is far too early to say yet whether any of the manufactured mineral and vitamin products can be used successfully as supplements to inferior natural foods over long periods. Experience has shown that they can be used to tide over certain emergencies, but even when they are used for this purpose they should be subjected to the supervision of the experiment stations.

Dr. D. B. Johnstone-Wallace, of Cornell University, in addressing the AAA annual meeting at Washington, D. C., July 12, 1940, stated the following:

By watching the nose-end of a good cow farmers can learn more about pastures and pasture management than they can from any agronomist or

[2] From "Food and Life," Yearbook of Agriculture, 1939.

animal husbandman. A good cow consumes 150 pounds of grass per day, using a "lawn mower" $2\frac{1}{2}$ inches wide. One hundred and fifty pounds of grass makes a heap 4 feet wide at the base and 3 feet high. It contains 30 pounds of dry matter. The consumption of a good cow per day .roughly approximates the daily production of an acre of grassland. Cows consume pastures 4 inches high much more effectively and rapidly than if it is 2 feet high.

Two million acres of English pasture, long-established, have been plowed up during the present year to increase the food production of England under present war conditions. The pastures of England have constituted her greatest emergency reserve supply of potentially available food.

In Cornell Extension Bulletin 393, Pasture Improvement and Management, Mr. Johnstone-Wallace makes the following recommendations.

THE TYPE OF PASTURE TO IMPROVE

At Cornell University good pastures are yielding annually from 4000 to 6000 pounds of dry matter to the acre, containing from 20 to 30 per cent of protein. Such yields are sufficient to justify the use of good land for pasture.

In the selection of fields for improvement, consideration should be given to their distance from the farm buildings, their accessibility to drinking water, and their adaptation for division into smaller fields to permit the adoption of a system of alternate grazing. Whenever possible fields should be selected that are sufficiently free from stones, stumps, and hummocks to permit close mowing.

Moderately level fields are desirable, and those sloping to the north and east are more productive during the hot summer months than are those sloping to the south and west, because lower soil temperatures are maintained. The best pasture land should be improved first, for after improvement has taken place much of the poorer land may not be needed.

Medium to heavy soils well supplied with moisture are better for pasture purposes than are the lighter and dryer soils.

Because of the importance of good grazing management involving periodical close grazing, it is essential to restrict improvement to an area that can be properly grazed with the stock available. As a rule, one acre of improved pasture is adequate for one cow or its equivalent during a grazing season of from five to six months.

Pasture improvement is not expensive, and on most New York farms the annual cost of fertilizer treatment need seldom exceed $2.00 for each cow or its equivalent maintained on the farm.

PASTURE FERTILIZATION

The Need for Phosphorus

The first essential in the improvement of pastures on all soils in New York State is an adequate application of available phosphorus. This can be supplied most economically at the present time in the form of superphosphate, but other effective forms of phosphorus may be used when obtainable at competitive prices.

The first application of phosphorus must be large enough to produce a vigorous growth of wild white clover and other pasture legumes, which play an extremely important part in pasture improvement. The application recommended is from 600 to 800 pounds of 20 per cent superphosphate to the acre, or an equivalent quantity of any other grade. This should be repeated at intervals of about four years.

Early fall applications are considered most satisfactory, but late fall and early spring applications are also successful.

The Need for Lime

Lime is second in importance to phosphorus in the treatment of New York pastures. The best condition for pasture growth is a soil that tests between *p*H 6 and *p*H 7. It is recommended that soils testing between *p*H 5 and *p*H 6 should receive an application of 2000 pounds of ground limestone to the acre, and that those testing below *p*H 5 should receive 3000 pounds. County agricultural agents in the State make such soil tests free of charge if requested to do so. Applications of limestone should be repeated usually at intervals of from four to eight years if further tests indicate the need.

The Need for Potash

New York pastures respond to potash less frequently than they do to phosphorus and lime. Potash deficiencies have been found most often on light sandy and gravelly soils and in fields that have been depleted in fertility by the removal of hay and other crops without adequate applications of manure or fertilizers containing potash. When potash is needed, it should be applied in the form of muriate of potash at the rate of about 100 pounds to the acre. This application may be repeated at intervals of about four years.

The Need for Nitrogen

The need for nitrogen in the improvement of New York pastures is usually as great as is the need for phosphorus. Fortunately, the nitrogen required can be supplied under New York conditions by encouraging the growth of pasture legumes by suitable fertilization and periodical close grazing. The most valuable legumes in New York pastures are wild white clover (*Trifolium repens* var.), wild birdsfoot trefoil (*Lotus corniculatus* var.), and yellow trefoil (*Medicago lupulina*). Of these, wild white clover is the most widely distributed and the most valuable. It is a wild form of the com-

mercial white Dutch clover from which it differs by possessing smaller leaves and flowers, by flowering later, and, what is of greatest practical importance, by being a true perennial that remains permanently in the pasture sward; whereas plants produced from seed of commercial white Dutch clover behave like medium red clover and seldom survive more than two years.

Some extremely poor pastures contain no wild white clover or contain less than an average of one plant to the square yard evenly distributed. In

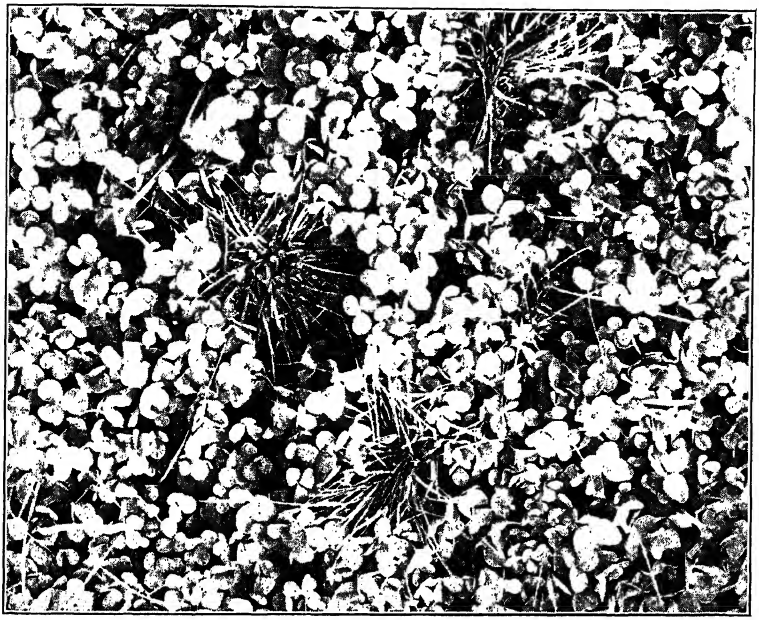

Fig. 38. An excellent new seeding of mixed grasses and clover. (*U.S.D.A.*)

these pastures it is advisable to introduce wild white clover into the sward by sowing 1 pound of seed to the acre in late March or early April. The seed may be mixed with sand, soil, or granulated superphosphate to facilitate even distribution over the surface of the pasture, and sown from a wheelbarrow or cyclone type of seeder. If the seed is sown sufficiently early, harrowing is unnecessary; but the field may be rolled to advantage. The seed should be inoculated with the type of culture used for red clover.

The importance of wild white clover in New York pastures is indicated by the results of experiments at Cornell University, which have shown that the addition of 2 pounds to the acre of wild white clover to a seeding of 24 pounds to the acre of Kentucky bluegrass has frequently increased the yield of dry matter by more than 500 per cent, while the content of protein and lime in the herbage has also been raised considerably. The amount of nitro-

gen supplied by the growth of wild white clover is so great that the herbage removed from an acre of good pasture at Cornell University in a grazing season usually contains nitrogen equivalent to from 1000 to 1500 pounds of sulfate of ammonia to the acre.

In addition to supplying nitrogen, wild white clover, because of the dense sward produced, results in lower and more uniform soil temperatures during the summer months than those in pastures with no clover. This leads to greater productivity. The dense sward also prevents erosion and loss of water by runoff from the surface during heavy rains. Wild white clover is so palatable that the pastures are grazed close and uniformly and weeds are suppressed.

New York wild birdsfoot trefoil is a highly productive perennial legume with a deep taproot. Attention was first directed to the value of this plant for pasture purposes as a result of its discovery by the author near Claverack in Columbia County during a pasture survey made in 1934. Since then it has been found in other extensive areas in the State, especially in Albany, Schenectady, Schoharie, Saratoga, Montgomery, Ulster, and Washington Counties. It frequently contributes more than 50 per cent of the herbage, and is valuable because of its productivity, palatability, and drought resistance.

Experiments with wild birdsfoot trefoil at Cornell University are giving promising results, and it has been found especially valuable because of its ability to continue rapid growth during periods of hot dry weather.

The New York wild variety has been found to differ considerably in habit of growth from the European cultivated variety and the English wild variety, both of which have been obtainable commercially. Because of the superiority of the New York variety, farmers in the State have been advised to harvest supplies of seed. A considerable amount has been produced in Albany County.

Yellow trefoil, although less valuable than wild white clover and birdsfoot trefoil, is a useful constituent of many New York pastures. It maintains itself in the pasture sward by seeding profusely even under close grazing conditions.

If the nitrogen required by New York pastures is not supplied through pasture legumes, the only alternative is to use fertilizers containing nitrogen or to make applications of manure. It is only under very exceptional circumstances that the high cost of the annual applications of nitrogenous fertilizers required when insufficient legumes are available, can be justified under New York conditions.

The Need for Manure

Applications of manure are especially beneficial to those pastures with thin swards that are on soils deficient in organic matter. Unfortunately, manure discourages stock from grazing pasture herbage, and unless precautions are taken more harm than good may result. In order to use manure to ad-

vantage, light dressings of from 8 to 10 tons to the acre should be applied in the fall to the whole of one field rather than to part only. The manure should be supplemented with superphosphate, and any herbage left ungrazed in late May or early June should be cut as closely as possible with a mowing machine.

The Cornell pasture mixture has been developed as a result of experiments at Cornell University and of experience obtained throughout the State. It has been designed with the object of producing a uniformly high yield of nutritious herbage throughout a grazing season of about six months. It is adapted only for soils adequately supplied with fertilizer and lime and for fields that will be properly grazed.

THE CORNELL PASTURE MIXTURE FOR 1938

	Pounds to the Acre
Kentucky bluegrass (*Poa pratensis*)	8
Canada bluegrass (*P. compressa*)	2
Rough-stalked meadow grass (*P. trivialis*)	1
Timothy (*Phleum pratense*)	6
Perennial ryegrass (*Lolium perenne*)	5
Yellow trefoil (*Medicago lupulina*)	2
Wild white clover (*Trifolium repens* var.)	1
Total	25

It is recommended that seed of New York wild birdsfoot trefoil (*Lotus corniculatus* var.) should be substituted for all or part of the yellow trefoil, especially in fields subject to drought, provided conditions justify the increased cost of the mixture.

The selection of the strains of each constituent used in the mixture is of great importance, and the following are suggested in order of preference, based on experiments at Cornell University. The use of several strains of each constituent helps to provide uniform growth throughout the grazing season.

Perennial Ryegrass

Swedish Svalof Victoria.
Norwegian Jaedersk.
Danish E. F. 79.

These varieties have been found to be sufficiently winter hardy and truly perennial under Cornell University conditions.

Timothy

Aberystwyth pasture S. 50.
Corstorphine pasture C. B. 191.
Aberystwyth pasture-hay S. 48.
Cornell hay 1777.

The two pasture types (Aberystwyth pasture S. 50 and Corstorphine pasture C. B. 191) are of special value because of their creeping habit of growth, which results in the production of a close sward and in the persistence of the plants under grazing conditions. Unfortunately, seed supplies are not plentiful. If improved strains are unobtainable, commercial timothy should be used.

Wild White Clover

Kent old pasture.

New York old pasture

Seed of these strains grown in New York should be certified by the New York Seed Improvement Association. Seed grown in England should be certified as Grade A or Grade B by the Ministry of Agriculture. Uncertified seed should only be accepted if it has been examined and approved by the Division of Seed Investigations, at Geneva, New York. This applies also to seed of strains of perennial ryegrass, timothy, and birdsfoot trefoil.

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CHAPTER X

GRASSLAND AGRICULTURE

During recent years of agricultural adjustment, it has been found necessary to devote more than 50,000,000 acres formerly devoted to corn, wheat and cotton produced in excess, to grasses and legumes. With the likelihood of further reductions in our acreage of crops which previously we exported and with the need of more soil-conserving crops to maintain our soil resources, the importance of grasses and legumes in our agriculture is greatly enhanced. Corn ranks highest of all our crops in producing food nutrients per acre for livestock feeding, and wheat and cotton are very important sources of concentrated feeds. A major shift to the increased use of pasture and roughage crops, therefore, will not necessarily increase total production of meat and milk, though more animals of certain classes, particularly of sheep and somewhat smaller carcasses which are in demand by the public, will result.

The chief advantages of a major shift to grasses and legumes lie in reduced production costs, the improvement in quality of meat and milk, and the better health of dairy cattle and livestock in general. The conservation and improvement of soil is greatly advanced by the increased use of pasture and meadow crops that protect the surface of the soil by retarding the runoff of rainfall and charge the land with organic matter. The advantages of a grassland agriculture were set forth in a series of five regional grassland conferences held during 1940. Following herewith are excerpts from the symposium of addresses presented by some of the nation's leading agricultural authorities.

GRASS AND SOIL IMPROVEMENT

Dr. M. F. Miller
Dean, College of Agriculture
University of Missouri

The North Central States originally included much of the best grassland in the country, and these lands are good partly because the soils are young and partly because they were developed under a heavy grass cover. The opportunities for a profitable grassland agriculture in much of the area cov-

ered by the North Central States are as yet incompletely explored, and these opportunities are probably far greater than is generally believed.

Experiments at the old field at Sanborn, representing fifty years of experimental work, have shown that the production of continuous corn has resulted in the loss of 56 per cent of the nitrogen supply of the soil during this fifty-year period, continuous wheat in the loss of 46 per cent, and a standard crop rotation without treatment has allowed the loss of 41 per cent

FIG. 39. A Virginia pasture of mixed grasses and clovers, mainly bluegrass and white clover, improved in yield by applications of lime and phosphate.

of the nitrogen supply. Continuous timothy plots harvested each year, with occasional re-seeding, have lost 27 per cent, and standard rotation plots heavily manured have lost 17 per cent of their original store of nitrogen. Only the continuous timothy plot, heavily manured, has remained at approximately its virgin content. Other Missouri data, representing a number of different soil types, mostly grasslands, show nitrogen losses varying from 23 to 41 per cent, with an average of 35 per cent. All of these cases include not only the losses to crops but also those due to erosion and leaching.

Dr. Jenny, formerly of the Missouri Experiment Station, compared virgin land with land long in use. One of these fields had been in production for 60 years, producing the ordinary crops of corn, small grain and timothy hay. The other field had never been plowed, and with the exception of some grass as pasture it was virgin land. The results show that under 60 years of exhaustive culture the surface soil of this prairie has lost 35 per cent of its nitrogen and 38 per cent of its carbon when compared with the virgin hay

land. The acidity of the cultivated soil had increased 0.33 *p*h, or 33 per cent, representing an equivalent of 3500 pounds of calcium carbonate. The cropped land produced only 24 bushels of corn as compared to about 38 bushels for the grassland.

In the use of grassland in soil improvement, not only are erosion losses minimized, but where lime is present there will be a definite accumulation of nitrogen in most instances, along with some accumulation of readily usable mineral nutrients. The conserving influence of grass is due to the decrease in erosion losses and to a tendency to accumulate rather than lessen organic matter and available plant nutrients.

The results of experiments of the Missouri Experiment Station show that erosion losses during 16 years under a bluegrass sod with a moderate slope were only three-tenths tons of soil per acre annually, while bare land lost 41 tons and corn 19.7 tons. At the Bethany, Missouri, Conservation Experiment Station, the acre loss of land under bluegrass sod with an eight per cent slope was but three-tenths tons annually, while bare land, on the other hand, lost 105 tons and land in continuous corn lost 67 tons per acre. In this same experiment the loss under continuous alfalfa was approximately the same as that under bluegrass. Similar results were secured in Wisconsin and Ohio, showing that grass reduces the loss from erosion to almost a negligible quantity.

Grassland farming demands proper soil treatment and proper utilization of the crop grown. In securing a stand of grass on poor lands particularly, proper treatments with lime and fertilizers are necessary. The future grassland system in the North Central States will be determined to a large extent by the new agricultural economy that may result from the war, and will also depend on the system of soil conservation that may be developed. If our soils are to be conserved, systems must be devised that will provide for greater soil cover than has prevailed during the last century.

Grassland farming means livestock farming with its very important stabilizing influence on agriculture. Livestock farming not only leads to a stable and conserving use of land, but good livestock has an important influence on people. Good livestock farmers are land owners or they have long leases. Under such conditions they develop a genuine love for the soil, without which no agriculture is permanent. Such systems promote the development of good neighborhoods, good country homes, good farm conveniences, good schools and good churches, all of which are necessary to a satisfactory rural life. Possibly these are the real contributions that grass and legume sods will make in the conservation of soil and human resources for the future.

GRASS AND LIVESTOCK PRODUCTION

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University of Illinois

Getting land back to grass is important from the standpoints of both soil conservation and the proper adjustment of our production for effective demand for agricultural products. Regardless of minor differences that may exist between basic philosophies of a national soil conservation program, we will agree that an effective program will result in still more land seeded to grass. Not only will more grass be grown as a means toward better erosion control, but better erosion control will result in more and better grass. With an increased proportion of his farm in grass, the farmer is faced with the greater importance of acreage returns from pasture and hay lands.

Any large shift from cultivated crops to grass tends to upset the old established economy. Already hay values and pasture rentals are definitely on a lower basis in some sections than they were a few years ago. This may be due to a natural lag in the adjustment of livestock operations to the changing relationship of cultivated crops and grass, or it may indicate the beginning of a long-time trend. It should be recognized that a marked trend toward an increased pasture husbandry may affect the quality of the finished product. So far as the dairy industry is concerned, a greater use of pastures and grass silage appears to improve the quality of the product, and the transfer of the yellow pigment, carotene, from the grass to butterfat, adds to its value. With beef production the results are different. Beef cattle finished for market on grass alone do not reach the high finish attained by grain fed cattle and the color of the carcass is less desirable, due to the yellow coat of fat produced by the carotene of the feed. Cattle fed grain on grass also show this yellow color and usually sell considerably below cattle finished in dry lot. Results of the Illinois Station show that there is no other valid reason for such discrimination and that lower prices paid by packers because of the yellow tinge in fat can be justified only because of public prejudice. Consumers should be educated to see the analogy between yellow butterfat and yellow beef fat, so that there may be less objection on the market to grass beef.

Sheep are next to cattle in importance as users of grass in this country, and may be finished for market at certain seasons of the year without the use of grain. Early spring lambs finished on pasture with little or no grain frequently top the June market. Western lambs are often satisfactorily finished on grass pastures with relatively small amounts of grain. While cattle use more of this country's total production of grass, sheep use more in relation to grain requirements than any other class of livestock. Records kept by 600 cooperators in the Illinois "Farm Bureau Farm Management Service" during a two-year period (1938–1939) furnish the following data on acres of hay and pasture used with one acre of corn and silage by different classes of livestock.

127 breeding flocks of sheep	13.6
68 breeding herds of beef cattle (calves included)	4.6
237 herds of dairy cattle	3.8
83 droves of feeder lambs	1.5
151 droves of feeder cattle	0.6
474 herds of hogs	0.2

The influence of these relationships on adjustments of livestock operations to a larger acreage of grass is, of course, very important. In some sections of Illinois there has already been a marked increase in small flocks of sheep. This appears to be a logical sequence of current shifts in relationship of grass and corn production.

While there are marked differences between species of livestock with respect to their ability to utilize grass and the percentage of their total feed requirements that may be secured from grass, it is probably true that in every case the cheapest nutrients come from effectively utilized pastures.

BREEDING BETTER PLANTS

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Chief of the Office of Forage Crop Investigations
United States Department of Agriculture

The plants that persist naturally in any given region over a long period of time are the ones that have been successful in adjusting themselves to the factors that limit the growth of vegetation. In order to survive in any given region, the plants would have to withstand the extremes in drought, cold, wind, insects, diseases, and competition with other plants common to the region in which they are grown. Those species and varieties of plants that can grow to maturity and reproduce in competition with other plants are the ones that are selected by Nature's "fit and try" process to cover the land. Darwin, in his writings, has given us a vivid picture of the "struggle for existence" and the "survival of the fittest." Nature has, over a period of hundreds of thousands of years produced an adapted vegetation that gives us a picture of the climatic conditions that have existed for the same period of time. The distribution of this natural vegetation is governed almost entirely by climate.

The crop map of the United States was developed by the farmers from the time they first settled on our eastern shores and began to destroy the natural vegetation and substitute for it various kinds of cultivated and grassland crops. This substitution began in the Eastern States and gradually progressed westward until practically all land of any agricultural value was covered with crops instead of the natural vegetation developed by Nature. When the farmers brought with them crop seeds from the Old World, they carried on a process of "fit and try" very much as Nature did to find out which crops were best adapted. The only difference was in time, the farmer

taking a few hundred years to make a pattern that took Nature many thousands of years.

The success of our agriculture is measured to a large extent by the degree to which we have been successful in substituting adapted crops for Nature's adapted vegetation. Naturally the farmer found, just as Nature did, that

FIG. 40. A comparison of a "deferred" grazing area and a heavily grazed area in a Nebraska range. The carrying capacity of western ranges is being increased by controlled grazing.

in certain regions the climatic and soil conditions were such that certain kinds of vegetation did better than others.

The new environment created by modern agriculture with its destructive tillage operations and plant pests needs new plants that are adapted to the changing conditions. The plant breeder is expected to develop these new plants in a relatively short period of time and within a relatively small number of plant generations. With the aid of scientific knowledge gathered from the fundamental plant sciences and from practical studies and observations made in the field, the plant breeder is able to mold new varieties better adapted to the ever changing environment that typifies our present cropping practices. Improved varieties with inherent potentialities to withstand the destructive effects of the more important limiting factors in crop pro-

duction naturally will yield more than the old varieties and will improve the crop value per acre without materially increasing the production costs.

Nature did not provide the soil with an inexhaustible supply of plant foods which could be drawn upon indefinitely by plants. Year after year, phosphorus, nitrogen, lime, and potassium have been removed from the soil with the harvested crops. It is not generally appreciated that animals grazing the pastures and then being sold away from the farm in the form of livestock and livestock products are also removing fertility. As a result, many pastures which were once productive have become so impoverished that they are no longer able to support a vigorous growth of forages. Pastures in the semi-humid and humid regions of the United States have gone through five different stages of impoverishment each followed by a lower production of forage of inferior quality.

The major changes in the first stage are depletion of organic matter, lime, and phosphate; in the second, loss of potassium; in the third, the failure of legumes and further decreases of organic matter and nitrogen; in the fourth, the encroachment of inferior grasses and weeds; and in the fifth, soil erosion.

GRASS IN FARM PRACTICE

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United States Department of Agriculture

Grass has always had an important place in American agriculture. But American agriculture for three centuries failed to recognize and provide that place to grass which it so richly deserves. Only during recent years, as a result of efforts to adjust agriculture to the consequences of the first World War, has grass been accorded the thoughtful consideration essential to its development and full utilization.

Today, faced by the impending consequences of the second World War, American agriculture recognizes that further and perhaps even more difficult adjustments are imminent. The part to be played by grass in effecting these adjustments is still problematical. Yet, in view of procedures that have been followed thus far in effecting agricultural adjustments, it is a fair assumption that grass will continue through the troublous years ahead to be the crop upon which America will rely in furthering her efforts to balance production while conserving her soil resources.

Despite the fact that approximately 60 per cent of the total land area of the United States is grazed at least part of the year—an indication of the already dominant position of grass in American agriculture—there is an unmistakable tendency to extend the grassland acreage of this country and wherever possible to incorporate grass as a crop in farm practice. Although this tendency derives largely from America's effort to adjust agriculture to a drastically changed and constantly changing international situation, it is sus-

tained and heightened by awakened public interest in soil conservation and the value of grassland in minimizing soil losses through erosion.

As already indicated, the task of extending notably the grassland acreage of America is not simple; and it is not likely to be accomplished rapidly. The regrassing of abandoned Western farm lands is no over-night job; and, even if faced by stern necessity, the South can not readily shift to a grassland agriculture. There are deterrent factors to be overcome, also, in other regions before adjustment to a grassland base can be fully accomplished.

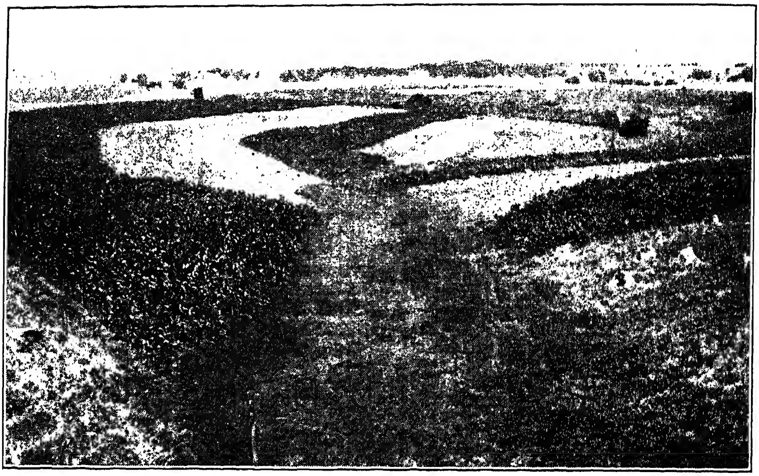

FIG. 41. Sod draws provide for regulated water runoff without gullying. (*Soil Conservation Service, U.S.D.A.*)

Again, it does not follow that the planting of more grass, and the production of better grass, will necessarily result in more livestock. I have pointed out the value of "idle" grass and the likelihood of many non-livestock farmers having to derive value from such grass if any value is to be derived. I have indicated also the difficult adjustment problem faced by some farmers who are not in a position readily to acquire livestock even if they want it. As for the farmers who already have livestock, I think there are few who could not make good use of more and better grass. At some of the grassland conferences experienced stockmen have emphasized the importance of not increasing livestock numbers simply because more grass, or better grass, is available. They advance the claim that with more and better grass the same number of livestock can be made profitable than more livestock.

This attaches to the feeling of other stockmen who believe that abundant, good grass is one of the surest ways of realizing cost reduction in livestock enterprises. And they have expressed themselves as believing that lower costs of production are as important to them as higher market prices.

This whole problem must be considered also in the light of consumer interest in meat and other animal products. The dietary requirements of urban populations, of even rural populations in some areas, are of paramount importance to the general social welfare. The consumption of more, high-quality animal products would be a boon to America.

I am not so zealous as to feel that grassland agriculture is easily adaptable to all farm conditions, in all parts of the country. I know that in some areas, grassland will have difficulty in establishing its place in farm economy. But granting its limitations in country-wide application, I cling to the belief that grassland agriculture affords more promise than any other type as a pattern for use in effecting agricultural adjustments. With such a pattern in mind, or upon paper, farmers individually, or in groups, would be better equipped than otherwise to make the best possible use of grass as a farm crop. They would grow better grass and get more out of it. They would have an understandable, workable and acceptable basis for balancing crop and livestock production. They would promote soil conservation and minimize soil erosion. And in realizing the personal or group benefits thus derived, farmers would insure to the nation adequacy in food supply while making the best possible use of our soil resources.

ADJUSTING GRASS CROPS ON INDIVIDUAL FARMS

Mr. C. R. Enlow
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It must be extremely difficult for a Corn-Belt farmer to appreciate the value of grass as a farm crop, particularly when he recalls the corn stories of his father and his grandfather. However, if he is observant, he probably has noticed that some of his land is not as productive as formerly, that it is more difficult to carry a crop through to production, and that on his thinner soils and sloping land, washing is becoming more evident. "The result of 40 years of hard farming" as depicted by the Ohio Experiment Station is illustrative of what is happening to the soil itself in the loss of organic matter, spore space, and why the soil is more difficult to cultivate; this can also be illustrated by actual comparison of soil samples taken under grass properly and improperly managed. The results from the Morrow plots of the Illinois Experiment Station point clearly to the losses the farmer is taking by failure to include grass crops in his rotation. They also bring out the importance of manure, lime, and phosphate with the rotation in improving organic content of the soil, and in improving the water holding capacity of the soil. The effect of a rotation and fertility program on the productive capacity of the farm is also well illustrated by projecting the results from the Morrow plots. Growing corn and oats without soil treatment has reduced the present effective size of a 100-acre farm to 64 acres, while a rota-

tion of corn, oats, and clover, plus manure, lime and phosphate has increased it to 128 acres.

Perhaps a good illustration of a method of procedure in adjustment can be drawn from a survey of 10,000 acres of wheat land in the Palouse country. A study revealed that 75 per cent of the land was producing 85 per cent of the crop at 65 per cent of the total cost. This means the remaining 25 per cent of the land was producing only 15 per cent of the crop at 35 per cent of the total cost, and certainly was being farmed at a loss. The low produc-

FIG. 42. Contour furrows, sodded over, improve pastures by checking runoff of rain water, increasing the moisture retained in the soil. (*U.S.D.A.*)

ing area consisted mainly of steep hillsides and clay hilltops—a hazard to the more productive land if continued in cash crops.

A study made in Iowa several years ago by the Iowa Station and the old Resettlement Administration resulted in a long-time recommendation of reducing the acreage of corn from 11 million acres to approximately 8½ million. It is my understanding this was recommended after carefully planimetering the soils and working out rotations that were considered capable of maintaining the soils. This approach is similar to the idea of "land use capabilities" projected in the soil conservation program, whereby the soil type, slope and degree of erosion are given consideration in planning rotations and supplementary practices. What is more logical than to take this approach on the individual farm, considering it carefully from the basis of land use?

The first big problem and the one that is the hardest for the farmer to meet, is the adjustment necessary to change his farm from his present system of farming to the grassland type of agriculture. Such a change should by all means, be based on careful analysis of the farm on the basis of soil, slope,

present condition of erosion, and also the economics of his farm setup. It may be possible merely to rearrange his fields to facilitate contour operations, and by changing rotation to meet the physical needs of the soil, work out a satisfactory plan without interfering with his needs for pasture, feed crops, and cash crops. This is usually not so difficult provided the farm is large enough to be considered as an economic unit, but if the farm is small and his rotations should be lengthened to include more years of sod crops, it frequently is impossible to work out a plan unless more land can be acquired.

In working out a plan, land that is practically level and in a good state of fertility can usually be maintained by a short rotation, including one year in sod crops. If, however, the land is sloping, it may be necessary to increase the sod crops to two or more consecutive years in the rotation. As the slope and erosion increase and the soil fertility decreases, the number of years in sod crops in any given rotation should be increased to a point where it seems necessary to convert cropland permanently to grass or trees.

Frequently, it is very evident that the acreage of grass on a farm should be materially increased in the adjustment program, in order to improve or maintain the soil, but through lack of land or the desire of a farmer to keep a higher percentage of his land in cash crops, it is not possible to increase the acreage of permanent pasture or the sod crops in the rotation sufficiently to take care of his needs. In such case, it is often possible to graze some of the regular crops, or plant supplementary pasture such as mixtures of Sudan grass and lespedeza, sweet clover, rape and other crops.

The entire matter of improvement of permanent pastures should also be given careful consideration in any grassland program. Our millions of acres of unimproved permanent pasture are mainly exercise paddocks and have little value from the standpoint of producing good feed.

MANAGING GRASSLANDS

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Like all biological problems of an applied character, the solution of grassland difficulties in any region is based primarily on the possibilities of environmental and hereditary adjustments. At the present time, the imperative needs of the grassland area in the North Central region are those of environmental control and regulation, but the immediate importance of ascertaining the most desirable species and of modifying the germ plasm of superior grasses and leguminous plants to fit the needs of an improved environment,. is clearly recognized and established.

Aside from its hereditary aspects, grassland management in its broad sense, is essentially a matter of vegetational control through environmental regulation. Although we cannot regulate rainfall, temperature or light under

field conditions, and although we cannot eliminate climatic hazards, we can employ those valiant biological devices of defense which come out of desirable managerial practices and the utilization of winter hardy, drought enduring, heat resisting, and disease tolerant species. They are indirect but highly effective weapons with which to meet severe and uncontrollable climatic hazards.

Difficulties with permanent pastures are associated primarily with four dominant aspects of the environment in the North Central States. They are *moisture, fertility, food reserves* and *insects.*

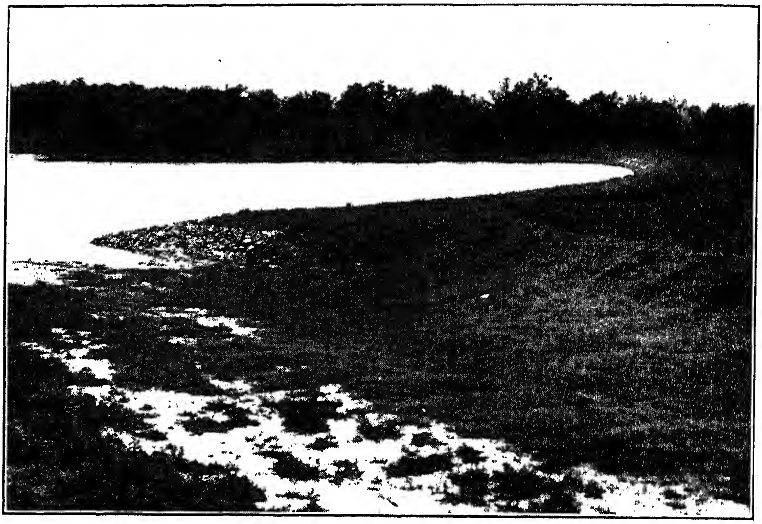

FIG. 43. Well-constructed stock-water ponds conserve water for use during dry periods. Bermuda grass protects the spillway of this Oklahoma pond.

Food reserves are so intimately associated and interrelated with all other limiting factors of growth that under field conditions it is often difficult to differentiate their responses from those drought, winter injury, infertility, or some other factor or factors. In controlled trials, however, they become manifest. Evidence of such relationships is indicated in a cutting trial at Madison, Wisconsin, during 1927 and 1928. A very dense and uniform sward of pure bluegrass was established on a moderately fertile soil which had been summer fallowed in 1925 and in 1926 up to July 22 when the area was seeded. In 1927, plats were cut six times with a lawn mower at a one-inch level. The first cutting occurred on April 6 and the sixth on June 24. Conditions were such that the six defoliations during the period of active succulent growth lowered the food reserves of the bluegrass in contrast to the adjacent plats which were cut only once when headed. This cutting was made with a field mower on June 24. The following year (1928) all the

plats were cut uniformly, once on July 7 and once on August 31. The current and subsequent responses in productivity to this modest differential in defoliation were measured on soil not fertilized and on soil fertilized heavily with a complete fertilizer in 1927 and with ammonium sulphate in 1928. The results were as follows:

NOT FERTILIZED

A. Six cuttings, Apr. 6–June 24, 1927	1241 lb. oven-dried herbage per acre
B. One cutting, June 24, 1927	2930 lb. oven-dried herbage per acre
A. One cutting, July 7, 1928	600 lb. oven-dried herbage per acre
B. One cutting, July 7, 1928	1722 lb. oven-dried herbage per acre
A. One cutting, Aug. 31, 1928	603 lb. oven-dried herbage per acre
B. One cutting, Aug. 31, 1928	1037 lb. oven-dried herbage per acre
Total—Treatment *A*	2444 lb. oven-dried herbage per acre
Total—Treatment *B*	5689 lb. oven-dried herbage per acre

FERTILIZED HEAVILY IN 1927 AND 1928

C. Six cuttings, Apr. 6–June 24, 1927	1376 lb. oven-dried herbage per acre
D. One cutting, June 24, 1927	3563 lb. oven-dried herbage per acre
C. One cutting, July 7, 1928	1962 lb. oven-dried herbage per acre
D. One cutting, July 7, 1928	3153 lb. oven-dried herbage per acre
C. One cutting, Aug. 31, 1928	2674 lb. oven-dried herbage per acre
D. One cutting, Aug. 31, 1928	3315 lb. oven-dried herbage per acre
Total—Treatment *C*	6012 lb. oven-dried herbage per acre
Total—Treatment *D*	10031 lb. oven-dried herbage per acre

Alfalfa for Hay and Silage

Alfalfa is extremely sensitive to cutting treatments. If the North Central States are to maintain their leading position in alfalfa culture, they will be obliged to follow more closely than ever the "straight and narrow path" of proper management.

Fall Cutting Reduces Summer Growth

In this trial, the yields from two deferred summer cuts of hardy Canadian variegated alfalfa in 1932, 1933, and 1934 were greatly reduced by previous fall cutting in 1931, 1932, and 1933, particularly where the alfalfa was grown on soil of moderately low fertility but without the fertilization of phosphate and potash. Such total summer yields per acre for three years (1932, 1933, and 1934) were as follows:

FERTILIZED WITH PHOSPHATE AND POTASH

A. Fall growth not removed—abundant food reserves and winter cover	9.82 tons
B. Fall growth removed in later October—abundant food reserves and little winter cover	8.98 tons

C. Fall growth removed in September and in October—low reserves and little winter cover 7.30 tons

NOT FERTILIZED

	A. As above	7.08 tons
	B. As above	5.37 tons
	C. As above	3.85 tons

The results illustrate the hazards of fall cutting in Wisconsin, particularly when it results in the lowering of reserves of alfalfa on soil of only moderate fertility.

Early Cutting of First Growth Very Hazardous

A matter of only 12 days earlier cutting (June 8) of the first growth of alfalfa for two years profoundly reduced the yields of the *first crop* when compared with deferred cutting (June 20).

FERTILIZED	*Deferred*	*Early*	*% Loss*
A.	4.56 tons	4.00 tons	12.3
B.	4.33 tons	3.23 tons	25.4
C.	3.52 tons	2.50 tons	28.9
NOT FERTILIZED			
A.	3.57 tons	3.34 tons	6.4
B.	2.48 tons	1.90 tons	23.4
C.	1.80 tons	1.11 tons	38.3

When fall cuttings (*B* and *C*) weakened alfalfa, early cutting for two years reduced the yields from 25.4 per cent to 28.9 per cent on fertilized soil compared with 23.4 per cent to 38.3 per cent on soil not fertilized. Whenever alfalfa has suffered winter injuries early cutting of the first crop is apt to be particularly harmful as the plant is not given sufficient opportunity to store foods and to heal over its winter sores.

Early Cutting of the First Growth Yellows and Stunts the Second Crop

Early cutting of the first growth may be extremely deleterious with respect to the productivity of the second crop as is indicated by the yields obtained from the second growth in a period (1932 and 1933) of two years.

FERTILIZED	*Deferred*	*Early*	*% Loss*
A.	2.97 tons	1.58 tons	46.8
B.	2.67 tons	1.31 tons	50.9
C.	2.24 tons	0.78 tons	65.1
NOT FERTILIZED			
A.	1.96 tons	1.20 tons	38.8
B.	1.67 tons	0.73 tons	56.3
C.	1.04 tons	0.44 tons	57.7

To complacently plan the management of hay fields and grazing lands from the viewpoint of optimum climatic conditions in the North Central regions is arm-chair thinking as futile and as disastrous as that which has brought nations to ruin but management that fortifies desirable grasses and legumes with high levels of fertility and productive levels of food reserves, is to be prepared for the emergencies of the environment.

THE SHIFT FROM FEED TO ROUGHAGE

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A shift in land use in farming which results in the production of more roughages and less feed grains has certain ascertainable effects upon livestock output and also upon livestock prices. Such a shift in cropping practices would change the price-cost structure of feed stuffs with roughages becoming cheaper relative to feed concentrates. How much cheaper they would become relatively is a function of two variables, (1) the amount of the shift in the use made of farm land and (2) the amount of substitution between roughages and concentrates in feeding livestock.

The first of these two governing circumstances need not detain us in this analysis since in all probability the shift in crops from feed grains to roughages is likely to be moderate, certainly within any five-year period. Farmers do not alter their cropping practices radically even when induced to do so through state and federal action programs. However, acreages transferred, for example, from corn to grasses do not reduce corn output proportionately, that is, a 10 per cent cut in the acreage in corn does not bring the output of corn down 10 per cent, simply because the best corn land is maintained in that crop and further because the improvement in rotations occasioned by more grasses has a favorable subsequent effect upon corn yields which further offsets the shrinkage in production resulting from a given cut in land devoted to corn. There is not likely to be nearly as rapid change in the proportions of the total feed supply as has been commonly supposed. We apparently will continue to produce in the Corn Belt a ratio of feed concentrates to roughages not greatly but only moderately different from that of ten or fifteen years ago.

Wilcox in examining the substitution ratio of roughages for concentrates in feeding livestock on Iowa farms found:

> Elasticity in the use of Iowa feeds by the different classes of livestock is sufficiently great to suggest that a ten per cent reduction in grain accompanied by a corresponding increase in hay and pasture will not, in itself, have any significant effect on the type of livestock and livestock products produced in Iowa.

The broad outline of what has happened as a result of the AAA program is plain. Farmers have changed their cropping practices quite markedly.

Corn acreage in the eleven Corn Belt States is down 42.8 million acres this year compared to 58.9 million during 1928–32, a drop of 27 per cent; however, because of the drouth economy forced upon South Dakota, Nebraska and Kansas not nearly all of this cut in corn is ascribable to the efforts of the AAA and SCS. Then, too, in the central and eastern Corn Belt States, especially in Iowa, Illinois and Indiana, soybean acreage has shot up enough to offset in large measure the decline in corn acreage. The change in oats has been downward but relatively less so than corn, as a matter of fact, a continuation of the long-time decline which was in process; while the acreage given to barley has stayed about the same with the acreage in hays up slightly.

Somewhat more precise and adequate data are available for Iowa because of the studies of Wilcox and Crickman. In 1940, Iowa farmers have 23 per cent less acreage in corn, 11 per cent less in intertilled crops and 23 per cent more in soil conserving crops than they had during the period 1929–33. It is noteworthy that this change in the cropping practices in the State was achieved although a fourth of the Iowa farmers were not participating in the program of the AAA this year.

The shift in acreages devoted to specific feed crops, however, substantially overstates the change that has occurred in the available feed supply. The combination of circumstances had tended to cancel out the apparent shift in the proportion of roughages to concentrates that the change in acreage would appear to have occasioned. The improvement in rotation, the use of better seeds, better cultivation, the maintaining of the most productive land on the farm in corn, along with exceptional corn-producing seasons have increased the per-acre yield of corn to fully offset the reduction in corn acreage. It is true, however, that as a result of the programs more and a higher quality of roughage has been available throughout much of the Corn Belt.

The corn loans have been sufficiently high relative to other feed concentrates and to roughages generally to have occasioned a considerable amount of substitution of oats, barley and in some sections, of low-grade wheat and also of rye and especially of processed feed concentrates, such as the mill feeds—for corn. Because of the fairly ample supplies of these feed concentrate substitutes, the incidence of the substitution has favored roughages less than would otherwise have been the case, yet nevertheless, the corn loans have probably induced a considerable expansion in the use of roughages.

The third and last class of influences ascribable to features of governmental action programs are those which have their roots in the subsidization of consumption of farm products. The most notable of these has been the Food Stamp Plan. Recent studies suggest that those consumers who have been given financial assistance through this plan are likely to allocate more of their recently acquired purchasing power to such farm products which require grasses to produce, such as meats and dairy products rather than shifting their additional buying power to cereals. While the basic principles which underlie the Stamp Plan have a great deal of merit as means to a betterment of the nutrition and health of low-income families, the net effect of the present programs upon the relative prices of farm products has undoubtedly been exceedingly small.

Credit institutions follow old grooves. Present and past experiences are not easily laid aside when new facts, new situations present themselves. To cite an extreme example in this connection, we may turn to another region. The credit resources now open to small upland cotton farmers in most of the South are virtually all based upon one crop, namely, cotton. On many of these farms every indication both of research of the Southern Experiment Stations, the experience of the agriculture in the immediate area and the pressure of the action programs is toward the semi-livestock form of economy

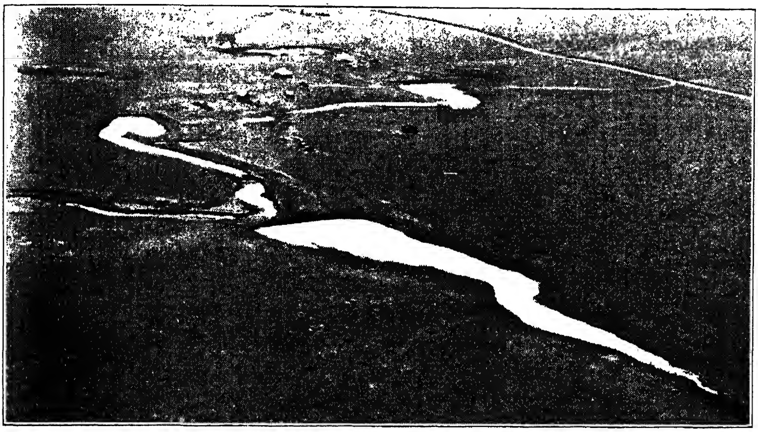

FIG. 44. Stock-water ponds in the western range country. Under the AAA range-improvement program, more than 60,000 of these ponds were constructed in four years in a territory extending from the Canadian border to Mexico. (*AAA.*)

and yet credit to facilitate this end is virtually non-existent and hence the shift from one crop, cotton, to feeds and livestock is greatly hindered.

Still another phase where credit impinges upon conservation practices is the general lack of emphasis on the part of credit institutions in their management of farm mortgages upon the maintenance of the productivity of the land resources on which the credit was advanced.

SOIL AND GRASS RELATIONSHIPS

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Ohio Agricultural Experiment Station

The fundamental difference between grassland farming and ordinary cropping lies in the nature of the vegetation itself. Instead of the man-controlled, stepwise sequence of species, usually annuals, characteristic of ordinary cropping, we have in grassland farming a dynamic "pre-climax" population of

species in which perennial grasses and legumes tend to predominate and in which the succession is determined by both the natural factors of soil and climate and by controls imposed by man. Such a population tends to evolve toward a type of "climax" population which in turn is determined by both natural ecological factors and man-controlled factors.

In addition to climatic and nutritional factors, management practices play an important part in controlling the plant populations of pastures and meadows. The effect of fairly close grazing or frequent mowing as against undergrazing and infrequent or no mowing upon the survival of white clover in competition with bluegrass is common knowledge. The tendency of too early or too late mowing toward the elimination of alfalfa from mixed alfalfa-grass meadows has been observed.

Another differentiating characteristic of grassland farming is the absence or infrequency of soil tillage. This permits, for more or less extended periods, the natural development of the root systems of the perennial plants. Associated with the development of roots probably occurs a cumulative development and stabilization of structural aggregates, especially in the finer textured soils. Also, with the progressive death and decay of the older roots increasing numbers of root channels are to be expected. Absence of tillage operations minimizes the breakdown of structural features.

Resulting from the thorough penetration of the soil by roots, from the efficient accumulation of soluble nutrients, and from the almost year-round activity of the vegetation, losses of nitrates and minerals from grasslands by leaching are extremely low. In the Cornell lysimeter studies, for example, nitrate losses in drainage under grass were only 4 per cent as large as under fallow.

Another feature of grassland is the high concentration of roots near the soil surface, which together with the progressive accumulation of residues on the surface, tends to emphasize soil structural effects in the immediate surface of the soil, to insulate the soil against temperature changes and loss of moisture other than by transpiration, and to center interest in this horizon as regards treatment with lime and fertilizers.

No characteristic differences exist between grassland and arable farming as regards minerals removed from the soil by growing vegetation. Removals of phosphorus and potassium by grassland crops and arable crops are likely to be similar on a given soil. An exception is the usually higher removal of calcium in high legume meadows or pastures. The important difference between the two systems lies in the direct return of mineral elements to the land in animal excrements in the case of pastures and the greater likelihood of such return being made in the case of meadow crops than of grain crops, since the former are more regularly fed on the farm. An analysis of the available data with respect to the recovery of fertilizing constituents of feed in fresh manure points to a recovery of about 80 per cent of the potash with dairy cows and of nearly 90 per cent with other classes of livestock. Recoveries of phosphorus are generally lower, owing to the greater utilization of this

element for growth or for the production of milk, wool, etc. Even so, reported recoveries with dairy cows average about 60 per cent and higher recoveries, up to 80–85 per cent have been reported for other classes of stock. Obviously, the return of such large proportions of the mineral elements contained in the herbage of pastures results in slower exhaustion of soil resources.

We now come to a question which has occasioned much speculation, but which is unanswerable as yet from direct experiment: "On grassland, capable of being tilled, should the sod be left unbroken, or should it be plowed at intervals and cultivated crops be introduced between more or less extended periods of grass?"

For the large number of fertilizer experiments on pastures and meadows in the North Central and Northeastern States certain generalizations may be drawn as follows:

1. The establishment and maintenance of the higher type pasture and meadow plants—bluegrass, white clover, alfalfa or clover alone or in combination with grass, etc.—require levels of available phosphorus, potash and lime comparable with those required for satisfactory production in rotation cropping.

Both lime and mineral fertilizers tend to stimulate the legumes in the grassland vegetation more than the grasses. In fact, following their application to depleted pastures, a marked increase in the proportion and growth of clover is often the only observable effect for one or more years after treatment, although with the resulting improvement of the nitrogen situation in such pastures, a gradual increase in the proportion of desirable pasture grasses generally follows.

Phosphorus is much more widely needed on permanent pastures than is potash although applications of potash are occasionally beneficial, especially in the earlier stages of improvement on depleted land. The response of grass meadows to phosphates and potash is usually meagre although often appreciable when used as supplements to nitrogen treatment. On the other hand, when alfalfa or clovers make up a considerable part of the herbage, excellent response to both phosphates and potash are common.

Consideration will be given one more problem, i.e., that of developing through breeding or selection strains of grassland plants whose mineral or nitrogen contents better meet the needs of livestock or strains possessing greater efficiency in utilizing soil or fertilizer nutrients. Recent work with white clover at the Regional Pasture Research Laboratory suggests that this species possesses sufficient genetic variability to make efforts along this line promising. In a private communication, Garber makes the following comments regarding this work:

> Robinson has found that clones of white clover vary significantly with respect to their phosphorus, potassium and calcium contents. Approximately 40 clones were studied first on a uniform, untreated soil in the greenhouse and then later a few of them on a soil limed and fertilized with minerals. All clones were higher in mineral content on the treated soil but the relative differences between clones were maintained. The more interest-

ing clones were then grown on very different soils with the result that in general, relative differences between clones were maintained.

It is conceivable that such breeding work might involve either or both of the following objectives: (1) the development of strains that contained larger percentages of the minerals required by livestock or contained them in certain desired proportions, and (2) the development of strains containing smaller amounts of the minerals required for plant nutrition assuming that such greater efficiency in the use of minerals could be attained without too much sacrifice in total yielding capacity.

GRASS

Senator John J. Ingalls

Next in importance to the divine profusion of water, light, and air, those three physical facts which render existence possible, may be reckoned the universal beneficence of grass. Lying in the sunshine among the buttercups and dandelions of May, scarcely higher in intelligence than those minute tenants of that mimic wilderness, our earliest recollections are of grass; and when the fitful fever is ended, and the foolish wrangle of the market and the forum is closed, grass heals over the scar which our descent into the bosom of the earth has made, and the carpet of the infant becomes the blanket of the dead.

Grass is the forgiveness of nature—her constant benediction. Fields trampled with battle, saturated with blood, torn with the ruts of cannon, grow green again with grass, and carnage is forgotten. Streets abandoned by traffic become grass grown like rural lanes, and are obliterated; forests decay, harvests perish, flowers vanish, but grass is immortal. Beleaguered by the sullen hosts of winter, it withdraws into the impregnable fortress of its subterranean vitality and emerges upon solicitation of Spring. Sown by the winds, by wandering birds, propagated by the subtle horticulture of the elements, which are its ministers and servants, it softens the rude outline of the world. Its tenacious fibers hold the earth in its place, and prevent its soluble components from washing into the sea. It invades the solitude of deserts, climbs the inaccessible slopes and forbidding pinnacles of mountains, modifies climates and determines the history, character and destiny of nations. Unobtrusive and patient, it has immortal vigor and aggression. Banished from the thoroughfare and field, it bides its time to return, and when vigilance is relaxed or the dynasty has perished, it silently resumes the throne from which it has been expelled but which it never abdicates. It bears no blazonry of bloom to charm the senses with fragrance or splendor, but its homely hue is more enchanting than the lily or the rose. It yields no fruit in earth or air, and yet should its harvest fail for a single year famine would depopulate the world.

CHAPTER XI

CONTROLLING WEEDS

Weeds are second only to soil erosion in the national losses to agriculture. Noxious weeds have become so unduly distributed by seed, livestock, water and other means, and many infestations are now so acute that they constitute a rapidly growing public, rather than an individual, problem. Yields are reduced, quality is lowered, cost of production is increased, and land values are destroyed.

Infestations get beyond individual control and infest neighboring lands. Tenant operation of farm land tends toward lack of control. County, State, and Federal lands are infested in many cases and become sources of infestation for agricultural areas.

This indictment of weeds was included in recommendations of the Western State Weed Conference at Caldwell, Idaho, on August 5, 1937, presented to the Secretary of Agriculture, stressing the need of federal assistance in making weed control a part of our agricultural conservation plans.

The actual annual loss caused by weeds is variously estimated as between $200,000,000 and $300,000,000. This includes the cost of excessive cultivation that is found necessary in order to hold down weeds and permit crop plants to develop; the cost of clipping pastures and mowing roadsides, stream banks, etc., to kill noxious weeds; the cost of cleaning seed, chemical weed treatments; and the cost of reduced prices received for weed-infested grains, seed crops, and hay constitutes a large part of the bill against weeds. There must also be included extensive losses of livestock, resulting from poison by certain weeds, and the losses in milk that is made unsalable, owing to pasturing on fields infested with plants, such as wild onion and bitter weed, that produce disagreeable odors in milk.

A weed has been defined as a plant out of place. There is merit in this definition, for weeds in their place are valuable as soil-conserving crops, particularly on abandoned, uncropped, or wild land. The Russian thistle thrives under the dry conditions of the western plains and aids in preventing the soil from blowing. When fire sweeps cutover

land or wood land, fire weed is the first plant that covers the ground. After several seasons other weeds, shrubs, various grasses and legumes, and seedlings will begin to appear. In the tobacco-growing counties of Maryland, tobacco growers consider a good growth of ragweed, stick weed, and other native weeds as the best crop to precede Maryland-type tobacco. Experiments by the Maryland Ex-

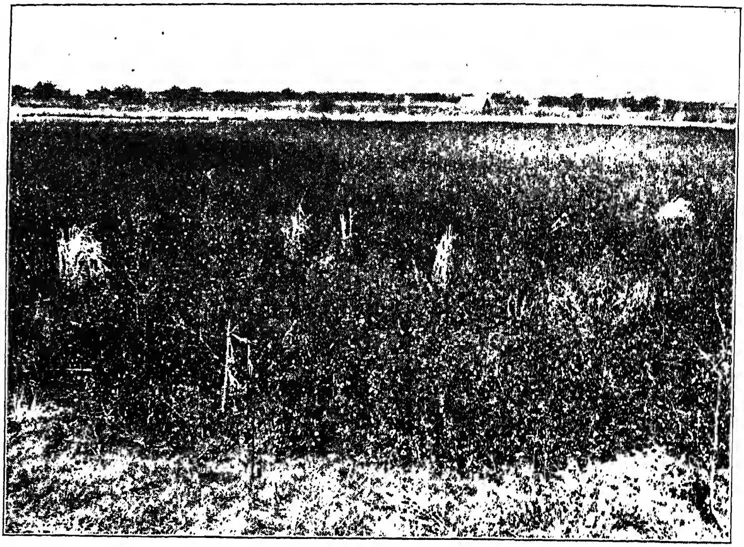

Fig. 45. Wet weather prevented this cotton field from being cultivated at the right time. Weeds and grass have taken over. (*Crop Insurance Corporation, U.S.D.A.*)

periment Station, with cover crops preceding tobacco, verify the judgment of the tobacco growers. Many kinds of weeds provide forage for livestock, but as a class weeds offer poor pasturage and hay compared with grasses and legumes with which they compete.

Certain plants, formerly considered weeds, when properly cultivated, have become valuable field crops. Sweet clover and yellow trefoil were formerly regarded as noxious weeds. Sweet clover is now widely grown for pasture, hay, and soil-building purposes, and yellow trefoil is now esteemed as a valuable legume to include in pasture seeding in Northern States. In Florida and the Gulf States, beggar weed is considered a useful soil-building legume. It is possible that other plants now looked upon as weeds will be found useful in the future.

KEEPING NOXIOUS WEEDS OFF THE FARM

Planting the seed of grasses, legumes, and grain that is infested with weed seeds has long been recognized as a major source of weed infestation. With no exceptions, the individual states have passed seed laws that prevent the sale, within the respective states, of seeds containing weed seeds designated as noxious. The present Federal Seed Act, effective since February 5, 1940, prohibits the importation into the United States of seeds containing the following noxious-weed seeds: whitetop, Canadian thistle, dodder, quackgrass, Johnson grass, bind weed, Russian knapweed, perennial sow thistle, leafy spurge. It also includes a provision requiring that seeds shipped in interstate commerce must comply with the legal provisions pertaining to noxious-weed seeds of the state to which the consignment is shipped.

Processed seed, sold by seed dealers under present conditions, rates high in freedom from noxious-weed seeds. The greatest cause of infestation through seeds is the planting by farmers of seed bought from neighbors, the locally grown seed not being cleaned to remove noxious weeds. This practice is exceedingly costly to many farmers in establishing noxious weeds that may require years of effort to eradicate.

Under present conditions, the feeding of feeds, particularly of molasses feeds, infested with noxious-weed seeds is a primary source of weed infestation. Screenings from grass and legume seeds and from grains are commonly included in certain molasses feeds, often without grinding or heat treating to kill the weed seeds. Hay and bedding purchased by farmers is frequently a cause of infestation by noxious weeds. Manure from cities and neighboring farms is frequently full of weed seeds. Separators of threshing machines and the drills brought on the farm from other farms should be carefully cleaned.

Wind will carry the seeds of Canada thistle, sedge, sow thistle, and Russian thistle from neighboring farms, and the water of streams and rivers will carry practically all weed seeds throughout the drainage area affected. Hence, the job of keeping weed seeds off the farm requires community cooperation in destroying all noxious weeds before they can go to seed.

THE KINDS OF WEEDS

Weeds are commonly divided into three classes: *annual weeds* that live but one year; *biennials* that live two years, making slow growth

during the first year and generally producing seed during the second; and *perennial weeds* that produce deep, underground roots that persist over a number of years. Ragweed, chess, pigeon grass are examples of annual weeds. The wild carrot and bull thistle are typical biennial weeds. Canada thistle, Johnson grass, and quackgrass are typical of the perennial weeds.

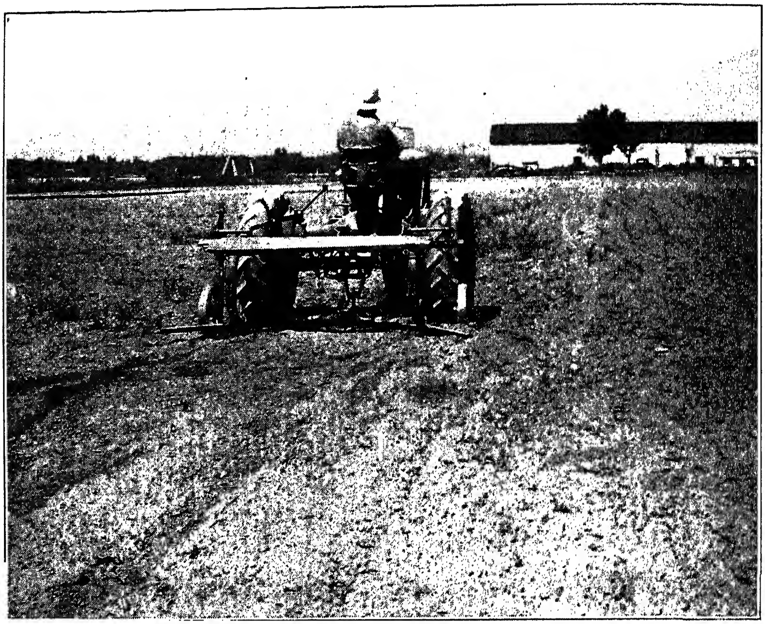

FIG. 46. Thorough cultivation of the seed bed is effective in weed control. (*Extension Service, U.S.D.A.*)

Annual and biennial weeds are controlled best if they are prevented from producing seed on the farm, either by thorough cultivation that kills out the weeds or by mowing before seeds develop. Perennial weeds are the most stubborn to control, and it is necessary not only to keep them from going to seed but also to prevent them from making top growth, thus starving out the underground parts.

WEED-CONTROL METHODS

Thorough tillage is the most effective way of dealing with weeds established on the land. The development of the modern-blade duck-foot type of cultivator adjustments and the use of rubber-tired trac-

tors have greatly increased the efficiency of weed control. Thorough preparation of seed beds and adequately cultivated crops are most effective in reducing many weeds. Meadows and pastures infested with bitterweed, Canada thistle, and other noxious weeds should be clipped before the weeds go to seed. In many cases smother crops, such as sudan grass and sweet clover, may be used effectively in killing out certain weeds, or else tar paper or building paper may be spread over small infestations of noxious weeds. Rotation systems that include alfalfa, clover, small grains, and cultivated crops are effective in checking weeds and reducing the cost of weed control.

Mr. H. R. Cox, of the United States Department of Agriculture, recommends the following weed-control principles.

> Good rotations and efficient farm practices will subdue weeds.
>
> Three main principles of weed control must be observed: (1) Prevent weeds from maturing seed on the farm, (2) prevent the introduction of weed seeds on the farm, and (3) prevent perennial weeds from making top growth.
>
> The principles are the main thing; the particular method employed is of lesser importance.
>
> Next to the principles ranks the man behind them. Many men make a start to clear their farms of weeds but give up too soon. Often the campaign is stopped when success is in sight, and the weeds soon recover.
>
> Clearing a farm of weeds, especialy perennials, is no easy task; it requires more than average intelligence and perseverance. If, however, one faithfully carries out a plan of attack based on the foregoing principles of weed control he can practically rid his farm of especially troublesome weeds without a great amount of extra labor and expense.
>
> Weed control is frequently a community problem, and for the greatest permanent success cooperation among farmers is required.

Great progress has been made during recent years, in controlling some of our worst weed pests, by the United States Department of Agriculture, the state experiment stations, and manufacturers of tillage machinery and chemicals. Advantage is taken of vulnerable periods during the growth of weed plants and susceptibility of weeds to certain chemicals.

The Control of Bindweed [1]

I. Methods of Control.

A. Chemicals.

B. Cultural Practices.

[1] Suggestions based on three years of work at Lamberton, Minnesota, by the University of Minnesota.

II. Chemicals.

A. Sodium chlorate has given best results. Apply either dry or as a spray.

B. Rates of application. Three to four pounds per square rod or 480–600 pounds per acre.

C. Time of application—July 20 to October 1.
Immediately after small-grain harvest is satisfactory. Dry application in grain stubble is ideal. Mow heavy stands of weeds and rake off before applying chlorate advisable. Never burn stubble prior to application.

D. Second applications. Do not repeat the treatment with chemicals until about July 1 or of the year following the first treatment.

E. Methods of Application.

1. Spray method satisfactory if sprayer is available.
2. Dry chlorate spreader patterned after Lamberton chlorate spreader; advisable where dry chlorate is used. On very small patches or retreated areas; plants may be treated by hand applications.

F. Fire Hazards.
All chlorates or mixtures containing chlorate are dangerous unless properly handled. Keep cans closed tightly. Never permit any dust, dirt, or oil to come in contact with the chlorate. Thoroughly wash all clothing; wet with chlorate spray before it dries. Wear rubber boots and a raincoat for protection.

III. Cultural Methods.

A. Black Fallow.

1. The duckfoot cultivator is the best implement. Other implements may be equipped with duckfoot shovels, such as a corn cultivator.
2. Start operations by plowing 5 to 6 inches deep about June 1. Cultivate thoroughly every two weeks until ground freezes. Repeat black fallow second year until eradication is complete.

B. Crops To Follow Fallow.

1. Plant rye or winter wheat September 15 in southern counties, or September 1 in northern counties of second year, or else plant corn in spring of third year.

2. Treat stray plants with chlorate during next season. In corn apply chlorate in June. In rye, apply chlorate immediately after harvest. These chemical treatments are on areas where eradication is practically complete.

C. Fall-Sown Competitive (Smother) Crops.

1. Crops—rye or winter wheat. Use winter wheat or rye only where adapted.

Fig. 47. Applying a chemical spray to eradicate bind weed in Utah. (*Extension Service, U.S.D.A.*)

2. Plow land 5 to 6 inches deep June 1 to 15. Fallow until September 15. Seed rye or winter wheat at heavy rates. Remove crop as soon as ripe, plow at once 5 to 6 inches deep, and cultivate with duckfoot every two weeks until September 15 when another crop of rye or winter wheat is planted. For complete control, this operation may be necessary for a third season. Check the week development at harvest time second year. If no weeds appear, fallow remainder of year and plant to corn or other row crops in third year. Treat stray plants with chlorate at time of cultivating corn.

D. Summer Competitive (Smother) Crops.

With heavy infestations, a full season of fallow for the first year, and fallow until July 1 of the second year may be advisable. Then follow with two years of fallow and summer competitive crops.

1. Plow land 5 to 6 inches deep—June 1 to 15.
2. Cultivate June 15 and July 1 and immediately sow summer crops. Sudan grass, millet, sorghum (amber cane), and corn, drilled solid with a grain drill, have proved effective.
3. If land is free from annual weeds, drill soybeans solid.
4. If soil is loose from fallowing, pack it with a cultipacker before seeding. This will speed germination and give a more uniform growth, thus enabling crops to compete with bindweed.
5. Follow Up.
   a. Repeat summer crops second and third years. Practice systematic fallow during early spring and late fall when crops do not occupy land.
   b. After cleanup, follow any cropping system desired. Treat any surviving bindweed plants with chlorate.

E. Alfalfa. Alfalfa may be grown successfully by plowing the land deep in the fall and fallowing until about July 15, when the alfalfa is seeded. A compact seed bed is essential. Alfalfa probably will not eradicate the bindweed, but may be expected to grow successfully under most conditions. Do not remove hay from the farm as mature seeds may develop.

IV. Seed Produced.

Do not permit bindweed to produce seed. Even after cleanup, be on the watch for seedlings and prevent their becoming established. Carelessness in this respect may lead to reinfestation, and after a few years conditions may be as bad as before control measures were undertaken.

The Control of Quackgrass

This tenacious grass in the Corn Belt and Northern States is best controlled by using an early spring-tooth harrow or cultivator provided with sharp-pointed "quackgrass" teeth that dig up the root stocks and leave them on the surface. After drying, the quackgrass

roots are raked into piles and burned. The cultivation should begin about the middle of June or during the early blossom time and must be continued at weekly or bi-weekly intervals until winter. Early harrowings are at shallow depth, but the later harrowings should run the full depth of the harrow teeth.

The following year, harrowings should begin in early spring and continue at weekly or bi-weekly intervals until the planting time for crops that provide heavy shade, such as buckwheat, sorghum, millet, sudan grass, and soybeans. These smother crops should be well fertilized in order to provide a luxuriant growth.

Smothering with Tar Paper. Some small patches of quackgrass may be killed out by covering with tar paper that is weighted down with two or more field stones or heavy poles. Other material, such as old tin roofing, and boards may also be used. After two or three months, the quackgrass will be cleaned out. This will be effective in handling small patches.

Chemical Control. Sodium chlorate has been found to be one of the most effective chemicals to use in killing quackgrass. It may be spread dry on the surface of the soil or applied as a spray, using a solution of 2 pounds sodium chlorate per gallon of water. Five hundred or six hundred pounds of sodium chlorate are required per acre. Dry treatments are most effective when made in late fall, and spraying gets best results during June and July as well as in the late fall. The treatment costs from $40 to $60 per acre, and hence is practical to use only in destroying small patches of quackgrass. Soil treated with sodium chlorate is affected for one or two years, and crops cannot be profitably grown during the treatment. Copious rains remove the sodium chlorate and restore the soil to productivity.

Caution. Dr. L. W. Kephart, in charge of Noxious-Weed Investigations, United States Department of Agriculture, issues the following caution in regard to the use of sodium chlorate:

> Sodium chlorate is harmless when in the original container. It becomes violently inflammable when mixed with organic materials. Extreme care must therefore be used that neither the solution nor the dry salt comes into contact with inflammable materials. This includes clothing, wooden floors, barrels, wagon beds, grain drills, hay, and all other combustible substances. Should such contact occur during spraying the exposed articles should be thoroughly washed before they have a chance to dry. If dry chlorate is spilled on a wooden floor it should be immediately and carefully removed. Failure to observe this precaution may result in serious injury to handlers of chlorate.

Sodium chlorate is not poisonous in the ordinary sense of the word, although cattle should not be allowed to graze treated areas if this can be avoided.

The Control of Crabgrass

Crabgrass is a major pest in Central and Southern States. The fact that this vigorous grass does not thrive in shade is the key to the most effective control measures. By encouraging other grasses to provide a week or ten days' heavy shade during spring or early summer, the growth of the crabgrass is greatly retarded. Three hundred pounds an acre or more of a complete fertilizer, applied in early spring and followed by a similar fall application, will usually encourage redtop, timothy, and other turf grasses to produce vigorous growth and discourage the crabgrass. Small patches may be shaded and growth discouraged by using tar paper and boards as advised for quackgrass. Sodium chlorate is also effective.

The Control of Canada Thistles

Clean cultivation, the growing of alfalfa or other vigorous crops that are frequently cut, and the use of sodium chlorate are the chief methods used in keeping Canadian thistle under control. The salting of thistle in pastures grazed by sheep is also an effective method of preventing the spread and retarding Canadian thistle. The United States Department of Agriculture recommends the spreading of 4 pounds of sodium chlorate per square rod after mid-September, as a most effective way of killing out Canadian thistle. Sodium chlorate is nonpoisonous, but is a source of danger, and precautionary measures should be employed in using it, as discussed on page 133.

Controlling the Wild Carrot

This weed of old fields and waste places is best controlled by preventing a spread of seeds. In pastures and meadows, wild carrot can be held in check by mowing when the plants begin to bloom. By clipping with a mower bar set 8 or 10 inches high, the lowest blossoms are cut and new sprouts are not likely to develop. If cut too close to the ground, new shoots will spring in the stubble. If the blossoms are carried so close to the ground, they cannot be clipped. Several years of mowing at the right time and of fertilization of the meadow or pasture to encourage grass growth will generally destroy the wild carrot. In cultivated fields, the wild carrot should be de-

stroyed before it produces seed. Waste places and roadsides infested with the wild carrot should be mowed before seeds develop. Sheep are recognized as protective allies in cleaning up wild-carrot-infested lands, since they graze so closely that wild-carrot seed formation is prevented.

CHAPTER XII

CONTROLLING CROP PESTS

Crop pests, diseases and insects, cause tremendous annual loss to American agriculture as a whole, and frequently cause the complete ruination of crops upon which the individual farmer is dependent. In the main, insect and disease losses are prevented or reduced by choosing resistant crops or varieties, by growing crops in rotation, and by maintaining clean cultural practices and adequate fertilization. Sporadic occurrence of plant diseases and occasional widespread development of insects must be dealt with by emergency methods of control. Effective practices and control measures have been developed to reduce losses from threatened injury by insects and plant diseases. Seed treatments that control both sources of loss have been developed.

The defense against crop losses from insects and diseases has been substantially established by scientists who studied the life histories of insects, found the vulnerable points in the development of fungus diseases, and have developed effective poisons or field practices that will prevent serious losses. Careful scientific investigations have also led to effective methods of seed treatments and to spraying and dusting practices with the right chemicals to control or reduce crop losses from plant diseases. The general principles of controlling insect and disease losses are treated in this chapter. Subsequent chapters, dealing with specific crops, will include control methods that are effective in preventing losses due to the depredations of insects and to disease attacks.

CONTROLLING INSECT PESTS

As crop production followed the plow westward and as cultivated crops replaced forest and sod and followed irrigation waters into the deserts, the insects of native plants attacked the new and abundant food supply with devastating effect. Grasshoppers in the Great Plains region and the Mormon cricket in Utah destroyed the crops of vast territories, and the Colorado potato beetle once threatened our potato crop. We also acquired great numbers of insects from Europe and from Asia. The hessian fly is supposed to have arrived

with the Hessians during the Revolutionary War, and until methods of control were developed, this insect made wheat growing precarious. The European corn borer made its first appearance a generation ago and since then has caused considerable loss in the Great Lakes and New England regions where corn is grown. The Japanese beetle and

FIG. 48. Corn on the left was severely injured by drought and grasshoppers. The grain sorghum on the right is better adapted to withstand these great enemies of field crops in the Northwest.

the Mexican bean beetle are recent importations that are proving difficult to control. The list of importations includes many others, such as the angoumois grain moth, cotton boll weevil, pea weevil, and various leaf hoppers. The number of insects that prey on our crops runs into the thousands, and the damage resulting from them to crops alone, in spite of the use of control methods, is variously estimated as $50,000,000 to $80,000,000 a year.

CONTROLLING INSECTS

Insects are kept under control and are prevented from destroying our crops of field and pastures by both natural and artificial methods.

Freezing weather during the winter destroys many species and prevents them from advancing northward. Cool, moist weather in spring or summer may cause bacterial and fungus diseases to spread rapidly, destroying great numbers of these pests and preventing threatened crop damage. Insects prey upon each other. Ladybird beetles were introduced into California to eat the scale insects. Parasitic insects that lay their eggs in the larvae of the corn borer aid in reducing the numbers of this pest. Birds are the greatest natural enemies of the insect world. Conservation methods that protect and increase the number of our song birds and upland game birds are of great value in holding crop-destroying insects in check.

The poisoning of insects has been found to be effective in preventing crop damage. In the early seventies, Dr. R. K. Kedzie, of the Michigan Experiment Station, first used Paris green successfully in coping with the Colorado potato beetle. Before that time insect-control methods were limited to picking the bugs off the plants or to throwing road dust or lime on plants to discourage the insects. During recent years many ingenious poison treatments have been developed. These consist of contact poisons, which destroy the living tissues of insects, stomach poisons, and respiratory poisons. Examples of contact poisons are nicotine compounds, lime sulphur, formaldehyde, and various oil, soap, and tar compounds.

Stomach poisons are effective in controlling the great majority of insects. Arsenic, lead, fluorine, copper, and mercury, used as sprays or dust, are effective poisons when eaten by insects.

Respiratory poisons, such as cyanide of potassium and carbon disulphide, are examples of poisons that kill insects when taken into their breathing tubes.

Special control measures are employed in coping with certain insects. Chinch bugs, which crawl in great numbers from one field to another, can be kept from entering a field by plowing a furrow around the field that will trap the insects. At intervals about a rod apart, holes dug with a post-hole digger will fill with great numbers. Crude oil, poured along the furrow, will prevent the insects from climbing out; or a log may be dragged along the furrow to smash the chinch bugs and provide a dust mulch that retards their progress.

After many years of research by numerous entomologists, the Bureau of Entomology of the United States Department of Agriculture recently developed an effective method of controlling the corn ear worm. Mineral oil is employed by use of a common oil can, and 1 or 2 cubic centimeters of oil are dropped on the silks at the tip of the ear about three days after the silks have drooped over and pollination

has been accomplished. The oil flows along the silks covered by the husk, and ear worms, working in the ear or coming later, are killed.

The hessian fly is controlled by planting wheat during fly-free dates. These dates are established by entomologists of state experiment stations for the wheat-growing sections. The corn borer is best controlled by turning under or destroying all corn stubble, stalks, cobs, or ears on the land before May 1, and by picking up and burning corn stalks in nearby pastures. New corn-harvesting machinery has been developed that cuts the corn stalks close to the ground, thus reducing the carryover of the larvae of the corn borer.

Plant breeders have developed varieties of crops that are resistant to certain insects. Hybrid-corn varieties, distasteful to the corn borer, have been developed by the Michigan Experiment Station. The Illinois Experiment Station has brought out a hybrid corn that is highly resistant to damage from the chinch bug.

Crop rotation, plowing, and cultivation effectively control a great majority of the insect pests of field crops. The white grub may increase to the point of damaging whole pastures and following crops of corn. Buckwheat, planted after the white-grub-infested pasture crops have been plowed, suffers little damage, and the grubs are starved out. The insects that affect the cultivated crops in rotation seldom damage the small-grain and clover and grass crops that follow in sequence.

Controlling Insects of Stored Grain

The angoumois moth, cadelle, and grain weevil that damage grain in storage are effectively controlled by using carbon disulphide. Liquid carbon disulphide should be placed in shallow pans on top of the grain, and the bins should be tightly closed. From 3 to 5 pounds of liquid carbon disulphide will produce enough gas to permeate 100 bushels of grain. This gas is highly inflammable and poisonous. The treatment should be followed by a second treatment one or two weeks after.

CONTROLLING THE DISEASES OF CROP PLANTS

The agriculture of America suffers a tremendous loss each year as the result of plant diseases which are caused by fungi and bacteria, practically all of which can be controlled by growing disease-resistant varieties and by rotation and control practices. Individual farmers,

in many instances, have suffered crippling losses by diseases that affect their major cash crops. The black stem rust of wheat frequently ruins the wheat crop throughout extensive regions. The potato crop is occasionally rendered unprofitable by the late blight. Stinking smut of wheat reduces yields and damages milling quality,

FIG. 49. Wilt may cause great losses to cotton in certain areas. Including cotton every fifth or sixth year in long-time rotations aids in controlling wilt losses. (*Crop Insurance Corporation, U.S.D.A.*)

greatly reducing returns to wheat growers. Beans are often ruined by anthracnose, a fungus disease, or by blight, a bacterial disease. Tobacco is damaged by fusarium wilt, and the flax wilt may cause complete loss in nonresistant varieties. The leaf spot of alfalfa and the powdery mildew of clover may greatly reduce the yield of these crops. Rye is often seriously damaged by ergot, a fungus disease. The corn crop suffers from diplodia that causes weak and sickly plants. Practically all these diseases can be controlled or greatly reduced in their effect by proper control measures, good farming practices, and the planting of resistant varieties. The practices that are found effective in reducing losses from plant diseases are as follows:

1. Grow crops in properly planned rotation.
2. Choose disease-resistant varieties.
3. Plant clean seed and treat seed with proper chemical treatment.
4. Practice clean farming methods, disposal of crop residue.
5. Fertilize to increase vigor of growth of plants.
6. Treat with chemical sprays and dust.

Rotate Crops to Control Disease. The bacteria and the fungi that affect certain crops can be killed by the planting of crops that are not affected by diseases caused by these organisms. Usually two or three years of the growing of immune crops will check or control diseases that affect particular crops. Potato scab and cotton wilt necessitate a longer period, and where these diseases are in the soil, rotations should be planned to include potatoes or cotton only every four or six years. Wheat included in a four-year rotation suffers much less from scab than wheat grown continuously or in a two- or three-year rotation. The growing of cotton in rotation every three or four years greatly reduces losses from root rot. The leaf spot of sugar beets and the blight of beans are held in check by including these crops in rotation every four to six years. Losses from corn smut are materially reduced when corn is grown in rotations, including small grains, clover and alfalfa, and pasture crops.

Clean Farming Practices Reduce Disease Loss. Plant diseases are carried over in stubble, straw, vines, and diseased seed. The scab and rust of wheat are carried over to succeeding crops in stubble and straw. The anthracnose of beans is carried to succeeding crops in infected bean pods and stems and shattered seed. Ergot of rye and wheat is continued by its presence in the residues and seed of diseased plants. Volunteer rye is often infested with ergot, and the organism that causes anthracnose and blight lives over on many weeds and grasses. Wild grasses and weeds, if uncontrolled, transfer these diseases to cultivated crops. Fall plowing and early spring plowing, the cleaning up and feeding of straw and roughage, and the destruction of weeds and volunteer plants greatly reduce the losses caused by many plant diseases.

Increasing Vigor of Growth by Fertilization. By supplying the elements of fertility needed for vigorous growth, the damage resulting from most plant diseases is materially reduced. The use of fertilizers, good cultural practices, and adequate drainage of the land reduce the loss from plant diseases.

Planting Clean Seed and Seed Treatments. Most plant diseases are seed borne. Scab and rhizoctonia of potatoes, wilt of peas, anthracnose of beans, scab of wheat, and, in addition, the smuts and ergot of small grains are carried in the seed. Planting clean seed from crops not affected by these diseases will greatly reduce losses in yields. Wheat that carries smut balls of bunt should not be planted unless thoroughly cleaned over a good fanning mill and treated with formaldehyde. The commercial production of seed peas and seed beans is accomplished on new lands in Northwestern States or the Great Lakes region in order to control the anthracnose and the blight of beans and the wilt of peas. Rye containing ergot should not be used for seed. Seed potatoes that show scab or rhizoctonia should not be selected for seed purposes and, if used, should be treated with mercuric bisulphide. Planting clean seed, free of disease, greatly reduces the possibility of disease loss. Adequate seed treatments are an additional precaution.

Disease-Resistant Varieties. Plant breeders of the United States Department of Agriculture, of the state experiment stations, and of the seed companies have achieved results of great value in the development of disease-resistant or immune strains of crop varieties. The United States Department of Agriculture, in cooperation with the Minnesota Experiment Station, has developed a type of wheat practically immune to the black stem rust. The Marglobe tomato, developed by the United States Department of Agriculture, is immune to tomato wilt. The ladak alfalfa and certain Turkestan alfalfas have a high resistance to the alfalfa wilt. Many native red-clover strains have a high degree of immunity to anthracnose as compared with European red clover. The Purdue Experiment Station golden-bantam hybrid sweet corn is immune to Stewart's disease and yields nearly double the yield of open-pollinated, golden-bantam seed corn.

CHAPTER XIII

SEED AND SEED GROWING

The planting of good seed is the most important single practice in the production of successful crops. Better results can be secured at a minimum of labor by giving careful attention to the selection of seed than by any other practice necessary in crop production. D. H. Otis, Director of the Agricultural Commission of the American Bankers' Association, states the following in regard to the importance of seed.

> The use of adapted, weed-free seed of high germination from high yielding disease-resistant varieties, by insuring greater certainty of yield and increasing the yield per unit of area and labor, lowers the cost of production, and the improved product resulting contributes to effective marketing.

The plants selected by a farmer are his partners in production. It therefore behooves him to choose seed that carries in its genes lines of heredity that represent the highest yielding, best adapted, most disease-resistant and finest quality of the crops that he selects to grow. A strong partner is better by far than a weak one.

Webster's Dictionary defines *seed* as follows: "In a broad sense a seed may be defined as any propagative portion of a plant whether of true seed and seed-like fruits or of tuberous bulbs, etc." A true seed consists of a small embryonic plant, containing food material within itself, or embedded in tissue that contains a store of food material and surrounded by a seed coat. Of the plants of the grass family the seeds (which include the small grains, corn, pasture, and meadow grasses, and the annual grasses, such as millet and sudan grass) consist of the *embryo* or *germ* and the *endosperm* or surrounding food material protected by an enveloping seed coat. The *embryo* consists of the *plumule* or upper part which develops into the top growth and permanent root system of the plant.

The lower part of the embryo produces the *temporary* or *seminal* roots which function until permanent roots develop. When seed is planted in a seed bed that provides proper conditions of aeration, moisture, heat, and light, *germination* or *sprouting* occurs; and the

scutellum or *cotyledon,* that part of the embryo next to the storage tissue or *endosperm,* through the secretion of enzymes dissolves or digests the stored-up food material in the endosperm.

In the legume seeds, such as the seeds of peas, beans, alfalfa, clover, etc., the two cotyledons make up the bulk of the seed within the seed coat, and no endosperm is present. On splitting the seed, the plumule and radicle are found between the cotyledons. In germination, the

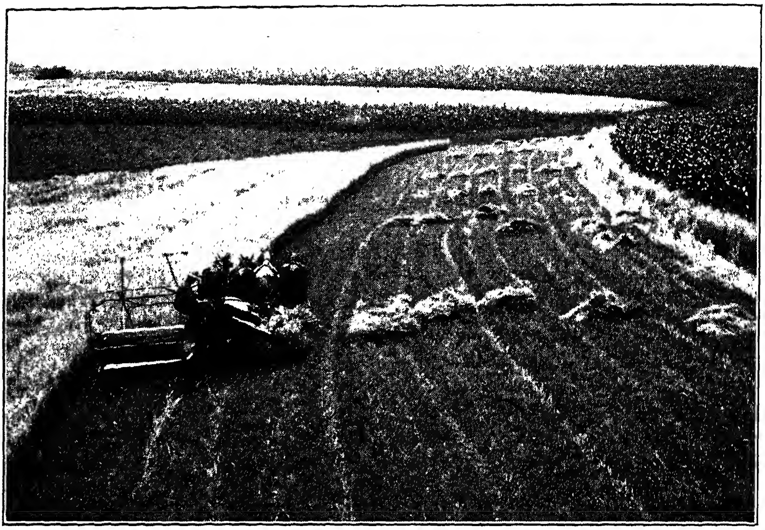

FIG. 50. Hybrid corn and certified varieties of small grains produced from seed under the inspection of state crop-improvement associations have resulted in greatly increased acre yields.

radicle pushes down and forms a permanent root system. As the plumules develop stem growth, the two seed halves or cotyledons are pushed upward, above the surface, and give up their stored food and drop off.

In the growth of peas and scarlet runner beans, the cotyledons remain under the soil surface, the stem alone being pushed above ground. The seeds of the entire grass family, corn, wheat, oats, barley, rye, timothy, bluegrass, etc., are *monocotyledonous,* having but one cotyledon. The seeds of the legumes, represented by beans, peas, clover, alfalfa, etc., possess two cotyledons and are termed *dicotyledonous.* Seeds of the legumes that are pushed above ground must be planted on thoroughly surfaced seed beds at comparatively shallow depths. The seeds of beet, mangel, and Swiss chard develop

in clusters. What is commonly termed a beet seed is a collection of two to six true seeds, bound together by a corky calyx.

Seeds require a rest period, ranging from several weeks to many months with the different plants, before they will germinate. Seed grains remain dormant for several weeks before they will germinate well. Germination of potatoes is improved by several months of dormancy under conditions of proper storage.

Hard seed is a term applied to seeds of clover, alfalfa, sweet clover, alsike, and other legumes which germinate only after a long resting period, owing apparently to hard seed coats not readily permeated by water. These hard seeds in clover and alfalfa seed are generally abraded, in the ordinary process of threshing, to a degree sufficient to permit the entrance of moisture through minute cracks in the seed coat and thus promote germination when planted. Special scarifying machines are in common use by seedsmen for conditioning lots of clover, alfalfa, and other legume seeds that carry a high proportion of hard seed. Scarified seed deteriorates in germination much more rapidly in storage than unscarified seed. Other seed treatments, involving chemical treatment with acids or other chemicals that thin the seed coat, have been developed. A higher percentage of germination is secured, but such seeds should be planted soon after treatment and should not be kept long in storage.

CHARACTERISTICS OF GOOD SEED

High quality seed should be free from weed seeds, dirt, and seed of other varieties of crops and should be free of seed carrying insects and diseases. Good seeds should have a bright, lively color and a wholesome odor and should show a high percentage of strong, live sprouts when tested for germination. Many of our most troublesome weeds were introduced in the early days of our agricultural history through the planting of crop seeds carrying noxious-weed seeds. Under present conditions, the high standards required by federal and state seed laws and the improved methods of cleaning employed by the American seed trade have greatly reduced introductions of noxious weeds through the planting of seed.

Many farmers, however, buy from neighbors seed that has been produced in weedy fields, without having the seed analyzed or seeing to it that it is cleaned over efficient seed-cleaning mills. Another great source of noxious-weed-seed infestation at the present time is the use of feeds, particularly molasses feeds, that contain screenings

produced in the commercial processing of weed seeds and grain. Seeds of bind weed and many other noxious weeds will pass through cattle without great impairment to germination. The use of feeds containing weed seeds that have not been ground or heat-treated to prevent germination introduces these seeds into the manure, stables, and feed lots, and thus to the field, often causing great expense

FIG. 51. A crimson clover seed crop. (*U.S.D.A.*)

through crop losses and the increased labor of many years to achieve control.

THE FEDERAL SEED ACT

The new Federal Seed Act became effective February 6, 1940. It includes clauses relating to seed in interstate commerce that require tags to be attached to packages of seed, giving a statement of percentage of weed seeds and of germination within a period of six months. The federal law upholds the noxious-weed seed law of individual states, into which the seed is shipped, in regard to the prohibition of the noxious-weed seeds. The federal law also prohibits misrepresentation as to variety, yielding ability, or other qualities applied to seed in interstate commerce. The new law includes a clause

to the effect that no disclaimer or nonwarranty clause used by the shipper or processor shall offset the requirements of the act.

The present Federal Seed Act prohibits the importation of seed containing the following specified noxious weed seeds: bind weed, Canadian thistle, sow thistle, leafy spurge, whitetop, quackgrass. It requires that the germination of imported seed shall exceed 65 per cent of live seed and that seed of red clover and alfalfa shall be colored to indicate origin. Seed of these crops, declared to be unadapted by the Secretary of Agriculture, such as red-clover seed from Italy, alfalfa seed from South Africa or Argentina, must be stained red to the extent of 10 per cent. Seed of alfalfa seed from Canada is stained violet to the extent of 1 per cent; and red-clover and alfalfa seed from other sources, 5 per cent green. The Secretary of Agriculture is authorized to require that seeds of alfalfa and red clover, and other seeds whose yielding ability depends largely on adaptation, shall be accompanied, when shipped in interstate commerce, by a statement indicating the state, territory, or foreign country where the seed is produced.

GROWING AND MARKETING SEED

The growing of seed as a special industry offers unusual opportunity to the right man on the right land. To compete with the highly skilled seed growers of the nation, the seedsman must not only be a good farmer skilled in the management of his soil and the cultivation, harvest, and storing of his crops, but he must also have highly specialized knowledge of the best varieties, resulting from plant-breeding work, and of crop disease and insect control. The seedsman must have knowledge of the best method of farm management, in order to handle crops and labor efficiently, and, in many cases, to combine seed growing with livestock feeding, dairying, or poultry raising, in order to utilize roughage feed, seed screenings, and other by-products and to aid in fertility measures.

The equipment needed on a modern seed farm includes the best of general farm equipment, such as the most efficient types of tractors, plows, harrows, cultipackers, and cultivators, drills, and harvesting machinery with special equipment for threshing, curing, and cleaning seed and for seed drying and storage houses.

The successful seedsman belongs to a highly intelligent group of farmers, engaged in the production of a high quality product for an exacting market. He must not only master production but he must also become efficient in the management of his seed plant, in prepar-

ing seed for market, and must be a good salesman of his product and anticipate new opportunities.

Growing and selling seed offers opportunities for the application of industry, intelligence, and highly developed skill, with assurance of higher financial recompense than is received by the general farmer and with the satisfaction of rendering a service to agriculture in producing and distributing good seed of superior heredity.

ISOLATING SEED FIELDS TO PREVENT CROSS POLLINATION

To prevent seed crops of open-pollinated varieties of field and truck crops from being mixed by cross pollination, it is necessary to isolate fields, used in the seed production, at distances of 40 or more rods from other varieties with which they may become crossed. Corn, rye, clover, alfalfa, melons, cucumbers, cabbages, and many other plants should be grown for seed in fields located at a sufficient distance from other fields of these crops to prevent cross pollination. By growing a tall-growing crop, such as corn or sorghum, between the seed crop and other crops with which it may cross, additional protection is given. Insects are active in accomplishing cross pollination, and proper isolation of fields will reduce this cause of crossing. Growers of rye, radishes, and sweet potatoes must destroy voluntary plants that may grow adjacent to the seed fields. Seed-corn growers should cut or detassel voluntary corn plants that appear near seed-corn fields.

TREAT SEED TO CONTROL DISEASES AND INSECTS

The use of cerasan or formaldehyde or copper carbonate in treating seed of small grains is advised in order to prevent losses from smut. Seed potatoes should be treated with mercuric bichloride to prevent scab, blight, and rhizoctonia. Seed growers should make a special effort to secure disease-resistant strains of varieties grown for seed, if available. Seed in storage, affected by weevils or other insects, should be treated with carbon disulphide before planting.

Seeds containing a high percentage of hard seeds, such as seed of clover, alfalfa, sweet clover, crotalaria, may be improved for planting by scarification or treatment with hydrochloric acid, or a combination of these treatments. The percentage of immediate germination may be considerably improved if the treatments are not overdone. Scarified seed should be planted shortly after the treatment since

germination may be injured if the seed is kept in storage from one season to another.

CULTIVATE SEED CROPS

In order to secure plump and fully matured seed and seed that is free from weeds, it is important that seed beds be thoroughly prepared, that planting be made at the right season, and that thorough cultivation be given the seed crop. The best types of seed drills, cultivators, and harvesting machinery should be employed. Care should be taken, in order to prevent mixing, not to lend drills used in planting seed to those who misuse them or fail to clean them thoroughly of seed.

When harvesting small-grain seed crops, small combines may reduce cost, but a better quality of seed grain is usually secured by harvesting with a binder and, after brief curing in the field, storing the seed for curing in a barn, under cover of a roof, or in well-made stacks. Seed growers find it advisable to own their own grain separators or bean separators. If an itinerant threshing machine is used, the ledges inside the separators should be brushed out after the first run, and grain to the extent of 5 or 10 bushels should be set aside from the main crop to prevent mixing.

ROGUING SEED CROPS

In producing seed of any type of crop, it is important that any off-type plants, diseased plants, or plants of other varieties should be pulled or hoed out, removed from the field, and burned or otherwise destroyed. Fields should be rogued several times or at each cultivation in order to keep plants of other varieties or off-type plants from mixing with the seed crop. Weedy areas that occur in seed fields containing such crops as alfalfa, clover, or lespedeza, which cannot be rogued economically, should be harvested for hay purposes and should not be included with the main area of the field that is harvested for seed.

HARVESTING SEED CROPS

In producing seed crops, it is important that seed of bright color and high germination be produced. Risks of weather damage that discolors seed and injures germination increase every day that the crop remains in the field. If harvesting is delayed, loss from shattering, birds and insects, and weather increases. Seed that is har-

vested before the proper stage of maturity is of light weight per bushel and frequently off color, below grade in appearance. Plump seed of good color, bright and lively in appearance, is produced by harvesting at just the right time and by curing and storing the seed properly to prevent weather damage. Efficient binders for small grains and mowers with binder attachment and vine-lifters for peas,

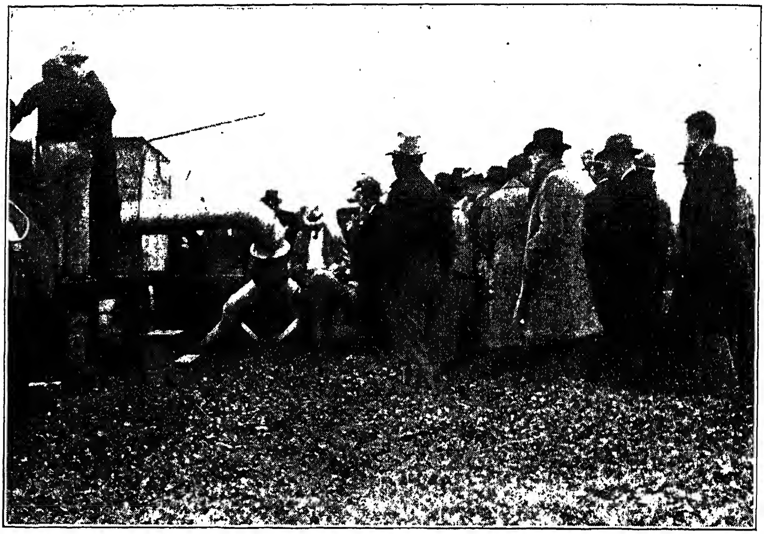

FIG. 52. *The county agent aids in demonstrating bur-clover threshing methods. (U.S.D.A.)*

vetch, and other viny plants should be used. Lespedeza is harvested with a special harvester, consisting of a small pan attached behind the harvester blade to catch the seed. Corn and sweet corn grown for seed are generally harvested by hand. It is also usual to harvest garden seed crops, beets, radishes, cabbages, and lettuce by hand, using hand clippers or reaping hooks.

CURING AND STORING SEED

Dryness is a primary essential in seed storage. Seed must be stored under conditions that provide good ventilation and freedom from the risk of freezing while damp, accomplished by the use of moving currents of warm air through the seed during early stages of storage in order to prevent loss from mold and dampness. Generally, seed of small grains and small-seeded crops should be dried as rap-

idly as possible to a point of 15 per cent or less moisture. Seed that is not properly dried will often heat in bins or sacks to the extent that germination is reduced. Seed-corn growers generally use artificial heat in drying or else place ears on hangers in seed houses or barns under conditions that provide free ventilation. The seed of garden seed crops is usually dried on racks or is spread thinly on canvas sheets on the floor of the seed house or barn.

Most seed growers find it profitable to construct a special seed house, equipped with drying racks, vermin- and insect-proof storage bins, fanning mill to clean seed, and screens to grade corn and other seed. Hand-picking machines are used by seed-bean growers. With a proper arrangement of bins and with the construction of chutes, cost of labor used in cleaning, handling, and sacking seed is greatly reduced. Particular attention should be given to the construction of ventilators in the seed house or seed room. Floors and sides of bins should be strong and should be made rat- and mouse-proof by the use of wire mesh or tin in the corners. Bins should be made tight so that they may be closed when treating with carbon disulphide to control storage insects.

The saving of labor in a well-arranged seed house and the prevention of loss from rodents, insects, and weather damage will soon repay the cost of construction of the seed house. In preparing seed for shipping to consumers or to seed warehouses, clean, strong bags should be used, with the shipper's tag placed inside the bag and another tag strongly attached outside. If used bags are employed, they should be turned inside out and thoroughly shaken to remove seed that may remain in the seams. Bags should be rolled at the top and sewed properly, rather than tied. The seed grower will find that all customers alike appreciate promptness in the filling of orders. Moreover, records should be kept on all orders and shipments for the protection of the shipper and for reference in developing future business.

STATE CROP-IMPROVEMENT ASSOCIATIONS

In the majority of the states of the United States of America and the provinces of Canada, seed growers joined in the organization of crop-improvement associations, experiment associations, or corn, alfalfa, ladino, or other seed associations, for the purpose of securing the best available varieties produced by experimental plant breeders or by private plant breeders and for enlarging their information in regard to the best methods of seed growing and marketing. These

associations maintain high standards through rigid systems of field and after-threshing inspections and certification. The associations cooperate with the agricultural experiment stations, extension services, and departments of agriculture of their respective states or provinces in maintaining high standards in the production and marketing of certified seed and in the effective increase of new and improved varieties constantly being developed by plant breeders. Membership in a crop-improvement association is an honor sought by many farmers and is exceedingly worthwhile not only from a business standpoint but also because of association with many men of high aims, purposes, and ability.

The crop-improvement associations in past years have dealt mostly with improved varieties of small grains, corn, flax, and potatoes. During the past decade, great advances have been made in the production of certified alfalfa and ladino seed and the seed of beans, sweet corn, and certain other truck crops grown on a field scale. At present, plant breeders of the federal government and the experiment stations are carrying on work that promises to develop highly improved strains of our leading grasses and legumes. As these become available for increase and for commercial distribution, a new and extensive field of opportunity will be offered to the seedsman of our crop-improvement association.

Many seed companies offer for sale certified seed produced by crop-improvement associations, and prefer to purchase their seed from members of the association or to place contracts for seed production with the trained seed growers.

> Human life and human progress depend, for continuance, upon the seed of cultivated plants conserved each year from harvest time to planting time. . . . No other factors are as important to the advancement of agriculture as the production and conservation for use of seed of high vitality of plant varieties of proven worth, and the creation of new and improved strains of crop and vegetable plants for the efficient feeding of domestic animals and the human race. The selection and care of seed constitute the most important of farm operations, and the seed industry is, in a sense, the most important of our basic industries.[1]

As an example of the constantly appearing improved varieties developed by plant breeders, the following list, from an exhibit of the Bureau of Plant Industry of the United States Department of Agriculture, January, 1941, is presented.

[1] Cox and Starr, "Seed Production and Marketing." John Wiley & Sons, Inc., New York.

NEW VARIETIES OF PLANTS

Bureau of Plant Industry Exhibit
U. S. Department of Agriculture
January, 1941

Alfalfa

Breeding for Resistance to Bacterial Wilt

A-136: Resistant when not inoculated and when inoculated.
Grimm: Susceptible when not inoculated and when inoculated.

Red Clover

Breeding for Resistance to Powdery Mildew

Resistant: Leaf cell collapses when invaded—spread of mildew stops.
Susceptible: Invaded cell remains turgid—mildew spreads over leaf.

Oats

Breeding for Disease Resistance, Yield, and Quality

Boone: New variety of oats derived from crossing *Victoria* and *Richland*. Resistant to smut, crown rust, and stem rust. High yield and high quality.

Victoria parent: From South America. Resistant to smut and crown rust. Low yield and poor quality.

Richland parent: Selection from Kherson from Russia. Susceptible to smut and crown rust; resistant to stem rust. High yield and high quality when not attacked by diseases.

Marion: New variety of oats from a cross of *Markton* and *Rainbow*. Resistant to smut and stem rust. Moderately resistant to crown rust. High yield and high quality.

Markton parent: Resistant to smut. Susceptible to stem rust and crown rust. High yield and high quality when not attacked by disease.

Rainbow parent: Susceptible to smut. Resistant to stem rust. Moderately resistant to crown rust. High yield and high quality when not attacked by smut.

The *Boone* oats were artificially inoculated with crown rust. Limited infection shows varietal resistance to this rust. It is resistant to stem rust also.

When artificially inoculated with stem rust, the *Marion* variety showed limited infection. Moderately resistant to crown rust.

Sorghum

Examples of Extreme Vigor in Hybrids

Dwarf Yellow Milo × *Blackhull Kafir* parent (hybrid—1st generation).

Blackhull Kafir × *Dwarf Hegari* (hybrid—1st generation).
Dwarf Hegari parent—from Sudan. Introduced by Bureau of Plant Industry,—now grown on 1,000,000 acres.

Tomatoes

Bonny Best: Wilt susceptible.
Marglobe (*Lycopersicon esculentum*): Wilt tolerant.
Peruvian Currant parent (*Lycopersicon pimpinellifolium*): Highly resistant.
Marglobe × *Currant:* 3rd backcross generation to Marglobe—highly resistant to wilt.

Potatoes

Sequoia: Flea beetle, leafhopper, and late blight resistant.
Katahdin: Bacterial brown rot and mild mosaic resistant.
Houma: Mild mosaic resistant.
Chippewa: Mild mosaic resistant.
Sebago: Late blight and mild mosaic resistant.

Sugar Beets

U. S. 200 (inbred) × U. S. 215 (inbred)—1st generation hybrid.
U. S. 215 " × U. S. 216 " — " " "
(American grown seed in 1942 will plant all sugar beet acreage in the U. S.)

Tobacco

Md. No. 407: Mosaic resistant.
Md. Broadleaf: Mosaic susceptible.

Rice

Varieties from Japan, Formosa, and Philippine Islands:

1. Fortuna.
2. Blue Rose.
3. Rexoro.
4. Nira.
5. Caloro.

Creeping Alfalfa

A promising pasture type introduced from Turkey.

Rubber

Guayule: Rubber shrub (*Parthenium argentatum*).
California, 1940.

Drug Plants

Suitable for growing in United States:

Belladonna (northern and western sections).
Digitalis (Pacific Northwest and many sections).
Ephedra (drier regions of the U. S.).

CERTIFIED SEED

The crop-improvement associations, through their inspection services, affix certification seals to bags containing seed, thus meeting the specified requirements as to variety, purity, germination, and seed conditions. In many states, the certification of seed of grains, forage crops, potatoes, and hybrid corn is provided by adequate legislation, and the seed is known as certified seed. State experiment stations generally provide for the substantial increase of improved varieties which are shown by careful test to be superior. This foundation-stock seed, or "elite" seed, is made available to outstanding seedsmen of the crop-improvement associations for increase in sufficient amounts to be furnished generally as foundation stock for certified seed growers. In some states, the term "registered" is used to apply to foundation-stock seed which has met the requirements of inspection. (Note Appendix, p. 443, Table of Certified Varieties by States.)

COOPERATIVE SEED MARKETING

Certified seed of the crop-improvement associations and seed of guaranteed origin, adaptation, and quality are widely distributed to such cooperative marketing associations as the Grange League Federation of New York, commonly known as the G.L.F., the Eastern States Cooperative, Inc., the Southern States Cooperative, Inc., and the farm bureau services of Ohio, Indiana, Pennsylvania, West Virginia, and

Fig. 53. A farmer cooperative local service unit. Feed, seed, fertilizers, and other farm supplies are distributed, and poultry, eggs, and other products assembled for shipment. (*G.L.F. of New York.*)

other states. These organizations, in the main, are farmer-owned stock companies whose main objective, in so far as seed distribution is concerned, is to provide patrons with high quality seeds of known adaptation and yielding ability. They make particular effort to secure the most recent improvements of high yielding, disease-resistant varieties. During recent years, truck- and garden-crop seeds have been included in the stocks handled by the farmer cooperatives, with special attention to effective seed treatments which control diseases and insects.

SEED DISTRIBUTION BY SEED COMPANIES

The majority of private seed companies make every effort to distribute high quality seeds, free of noxious-weed seeds and high in purity in accordance with adaptation. In spite of established federal and state seed laws, a small minority of seed dealers find ways of selling inferior seeds, often charged with noxious-weed seeds, without regard to soil and climatic adaptation. The American Seed Trade Association joined with farmer cooperatives and with the United States Department of Agriculture and the American Seed Analysts' Association in preparing recommendations to the Agricultural Committee of Congress that resulted in the passage of the present Federal Seed Act, which aims toward the discouragement of unethical practices in the commercial distribution of seed. American ingenuity in invention, plant-breeding technique, processing methods, business organization, and sales distribution has contributed in the development of the American seed trade on a high plane of service.

The record of hybrid-seed corn, a product of scientific investigators and seedsmen, is most remarkable.

In 1933, about 40 thousand acres were in hybrid corn in the United States; 6 years later approximately 24 million acres were grown—roughly one-fourth of the national corn acreage. About 55 per cent of the total corn acreage in Ohio and Illinois and 75 per cent in Iowa were in hybrids in 1939. Probably 80 to 85 per cent of the corn acreage eventually—perhaps before 1950—will be planted to hybrids in the Corn Belt.

CHAPTER XIV

PRODUCING A HOME-FARM FOOD AND FEED SUPPLY

We must never forget that the farm is a business; neither must we forget that the farm is also a home and that business and family living are intertwined in an inseparable way.

—DEAN C. E. LADD

The American standard of farm-family living is a rich heritage from our forefathers of generous and hospitable home living, made possible by an ample and varied farm food supply. Our early settlers, coming from the old countries of Europe, brought with them the fruits, grains, vegetables, poultry and meat animals, and the recipes for preparation for the table, handed down from generation to generation for centuries in their homelands. From the Indians of the New World a remarkable variety of new food products was added to this varied supply—the Irish potato, sweet potato, tomato, sweet corn, kidney, field and lima beans, pumpkins, varieties of squash, hickory nuts and pecans, huckleberries, cranberries, and the turkey—all previously unknown to the Old World.

The supply of plants that contribute to the American table has been further augmented and improved by the findings of plant explorers, sent out by the United States Department of Agriculture to the far corners of the earth to bring back new fruits, vegetables, and other plants of promise; and also by the contributions of plant breeders of the United States Department of Agriculture, state experiment stations, and American seed companies.

In pioneer times nearly all the food of the farm family was of necessity produced on the farm, supplemented by the game and fish from the woods and streams. Under modern conditions of rapid transportation and of readily available refrigerated, quick-freeze, canned, preserved, and dried products, people living on the farm are dependent on home food production only in so far as they find it economical and practical. Modern dietitians urge more fruits, vegetables, eggs, and fresh meats—the vitamin-carrying protective foods—and an ample homegrown supply of fresh eggs and fruits, fresh milk and meats, vastly improves the family diet and provides for gen-

erous usage. The greatest return from a well-planned farm food supply is in improved health, resulting from an ample and balanced diet. It is estimated, however, that $200 to $400 in annual monetary value may be secured by a farm family from a well-planned, yearly farm food and feed program.

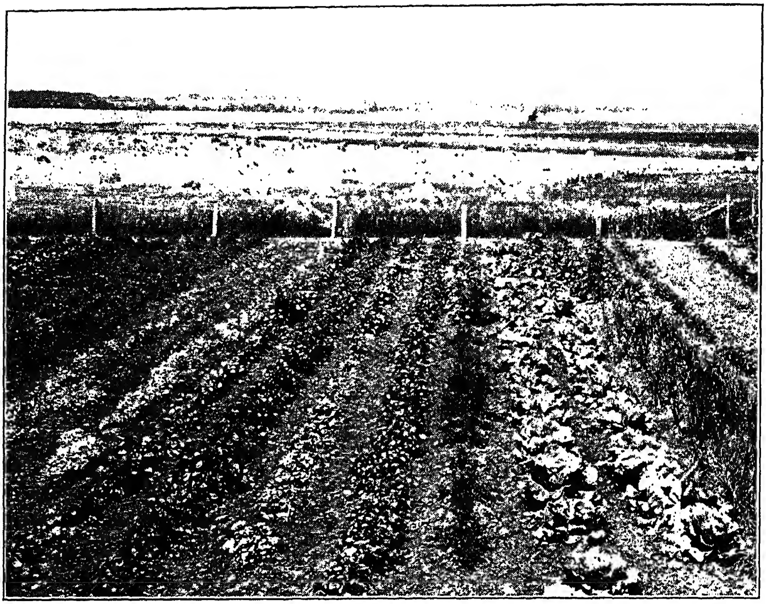

Fig. 54. The farm garden is a great asset to prosperous farm-family living. During the second World War, farmers were called upon to increase the number of farm gardens from 4,431,000 to 5,760,000. (*Extension Service, U.S.D.A.*)

Farm living is enriched by the proper use of living things—plant and animal—in close association with home life. The use of fruits and vegetables from the garden; nuts, berries, game, birds, and animals from the fields and woods; and fish from ponds and streams add variety and interest to farm living. Properly set-out plantings of trees, shrubs, and flowers in the yard, or trees for windbreak purposes, add beauty and protection to the farm home.

PLANNING THE FARM PROGRAM FOR FOOD AND FEED CROPS FOR HOME-FARM USE

There is no phase of farm production that requires a greater degree of planning than the farm home-produced food supply. Modern

farming is a highly specialized business. The greater part of the work is done by machinery. Hence the pace of living is stepped up—the pressure of work causes many farm families to neglect to plan and execute the year-round program of planting, cultivating, harvesting, and care that is necessary to make full use of the possibilities the farm offers of producing an economical food supply. Table 8, pre-

FIG. 55. The long-row garden can be cultivated with horse- or tractor-drawn machinery. (*Extension Service, U.S.D.A.*)

pared by the Illinois Agricultural College, gives the amount of vegetables and fruits needed per person for the farm family.

Much of this supply can be drawn from general fields, or garden crops may be planted in long rows with other cultivated crops—greatly reducing the work necessary for production. Many farmers find it advisable to plant only perennial plants—berries, rhubarb, asparagus, etc., and such greenstuffs as beets, spinach, Swiss chard, string beans, lettuce, and radishes in garden plots near the house. In these days of pneumatic-tired farming, with automobiles, trucks, and tractors available on most farms, such crops as potatoes, tomatoes, peas and beans, sweet corn, melons, squash, and pumpkins can be grown on the best suited soils and under field conditions that will

TABLE 8 *

A PLAN FOR THE FARM-FAMILY FOOD SUPPLY

Foods	Suggested Servings per Person		Approximate Amount Needed for a Liberal Supply per Person per Year					Approximate Amount Needed for Your Family
	Adults	Children	Unit of measure	Active man or boy over 14	Active woman or girl over 12	Child 8 years	Child 3 years	
DAIRY PRODUCTS								
Milk	1 to 2 pt. daily	1 qt. daily	gal.	70 to 90	70 to 90	90	90	
Cream and cheese	*Part of the above milk may be used in these forms.*							
Butter	$\frac{3}{4}$ lb. weekly	$\frac{1}{8}$ to $\frac{3}{4}$ lb. weekly	lb.	40	30	25	10	
VEGETABLES (Fresh, canned, or dried)								
Tomatoes	6 times weekly		lb.	100	100	100	75	
Green, leafy	6 times weekly		lb.	70	70	70	50	
Root	6 times weekly		lb.	100	100	100	50	
Dried beans, peas	2 times weekly		lb.	10	5	3	. .	
Potatoes	2 times daily	1 to 2 times daily	lb.	180	110	110	90	
Others	3 times weekly		lb.	60	60	60	25	

FRUITS (Fresh, canned, or dried)	2 times daily	lb.	220	220	220	125
POULTRY AND EGGS						
Chickens, ducks, etc.	Once weekly	lb.	25	25	25	5
Eggs	10 weekly / 1 daily	doz.	40	40	30	30
MEAT AND MEAT PRODUCTS						
Beef, veal, lamb (fresh or canned)	3 times weekly	lb.	55	55	40	7
Pork (fresh, salted, smoked)—sausage	4 to 5 times weekly / 1 to 4 times weekly	lb.	80	70	25	3
Lard	*Moderate amounts in cooking.*	lb.	25	15	5	..
CEREAL PRODUCTS						
Flour	*As bread, biscuits, etc., every meal.*	lb.	145	55	25	15
Cereal	*For breakfast daily; frequent use in combination dishes.*	lb.	100	75	50	32
SWEETS						
Sugar (including that used in canning and preserving), molasses, syrup	*Moderate amounts* / *Small amounts*	lb.	80	60	30	7
MISCELLANEOUS	*Beverages, condiments, baking powder, etc. Since these items will be used in variable quantity and must be purchased, no estimate is given.*					

*Extension Service in Agriculture and Home Economics, College of Agriculture, University of Illinois.

require the least work, at distances from the farm house that would have been uneconomical in the early days.

Long-row gardens are being planted to an increased degree on mechanized farms. Larger gardens that permit the use of field-tillage methods can be planted, and wider range is offered in selecting the garden site—all but perennial crops can be planted as part of any cultivated field.

The University of Illinois suggests the plan shown in Table 8 for the farm-family food supply, from the garden, from fruits, dairy products, meats, and cereal products.

The Illinois Experiment Station further suggests the planting of the long-row farm garden, designed to reduce the labor of gardening and supply the family with a large assortment of vegetables for year-round use. One-half or two-thirds acre of land that is devoted to vegetables, planted under the long-row system and cultivated with

Fig. 56. W. R. Beatty of the United States Department of Agriculture has long been one of the nation's leading advocates of the thorough fitting of the garden seed bed and of the careful planting of seed. (*Extension Service, U.S.D.A.*)

horse- or tractor-drawn tools will yield more in its return than any other area of similar size on a farm; and, in addition to the money value, it will produce advantages in terms of health, resulting from an abundance of vegetables in the diet.

In the "Land Policy Review," Mr. Oscar Steanson's article, "Square Meals from Spare Acres," presents the acreage needed to provide for family diets in Southern States.

SQUARE MEALS FROM SPARE ACRES[1]

Oscar Steanson[2]

Table 9 gives the estimated acreage per capita of cropland and pasture needed to supply diets, together with that actually used in 1937 in States in the AAA's southern region (excluding Florida): Per capita (farm population) acreage of crop and pasture land needed to supply the farm-grown portion of minimum-adequate diets,[3] used in 1937 for that purpose, and available land resources.

It will be observed that the acreage of cropland in food and feed crops

TABLE 9

Class of Land	South Carolina	Georgia	Alabama	Mississippi	Louisiana	Arkansas	Oklahoma	Texas
NEEDED FOR DIETS:	(Acres)	(Acres)	(Acres)	(Acres)	(Acres)	(Acres)	(Acres)	(Acres)
Cropland	2.6	2.9	2.8	3.0	2.9	3.1	3.5	4.1
Pasture, total	2.5	3.2	2.7	3.2	1.9	2.4	5.7	5.5
USED IN 1937:								
Cropland	2.0	2.7	2.6	2.2	2.2	2.5	3.1	3.3
Pasture, total	1.5	2.5	2.4	1.9	1.2	1.9	4.9	4.3
LAND RESOURCES:								
Cropland, total	5.6	7.7	6.0	5.7	5.5	6.7	16.8	15.2
Pasture, plowable	0.4	0.7	1.0	1.4	1.3	1.3	2.5	3.3
Pasture, woodland	1.4	3.1	2.2	2.6	1.4	2.2	4.2	10.2
Pasture, other	0.4	0.6	0.5	0.9	0.5	0.6	9.2	28.8
Woodland, not pastured	4.6	5.2	3.8	3.1	2.6	3.3	0.6	0.6
Other land in farms	0.6	0.7	0.7	1.0	0.8	0.9	1.5	0.9
Total land in farms	13.0	18.0	14.2	14.7	12.1	15.0	34.8	59.0
Land not in farms	7.6	8.7	9.5	7.5	21.7	13.5	8.9	13.0
Total land area	20.6	26.7	23.7	22.2	33.8	28.5	43.7	72.0

[1] From "Land Policy Review," July–August, 1939, Vol. II, No. 4.

[2] E. L. Langsford worked jointly with the author in developing the data upon which this paper is based.

[3] Acreage needed to feed all horses and mules included in calculations of diet requirements and used in 1937.

TABLE 10

Tennessee Live-At-Home Plan

Food Requirement Based on Moderate-Cost, Adequate Diet, Farmers' Bulletin 1757, Diets	Amount Needed for One Person for One Year	Yearly Amount for Family of Five (Two Adults, Three Children)	How To Provide for Family of Five
Dairy Products: Milk 1 qt. each child daily Milk 1 pt. each adult daily Butter $\frac{3}{4}$ lb. weekly per person Cheese $\frac{1}{4}$ lb. weekly per person	187 gal. milk	365 gal. for fluid milk, milk drinks, and cooking 488 gal. for butter making 83 gal. for cheese — 936 gal. total	Two good cows, fresh at different seasons, should furnish an ample supply of milk and some to sell as milk, cream, or butter
Eggs: 3 or 4 a week for adults 4 or 5 a week for young children A few for cooking Poultry: Served once a week One turkey a year	480 eggs	2400 eggs from 30 hens Average 1 hen—80 eggs	Hatch or buy 100 baby chicks each spring; develop pullets for layers; eat cockerels and cull pullets
Meat, Fish, Etc.: About 5 times a week	48 lb. beef 70 lb. pork 7 lb. lamb	240 lb. beef 350 lb. pork 35 lb. lamb — 625 lb. total	1 beef—450 lb. live weight 3 pigs—600 lb. live weight 1 lamb—75 lb. live weight

VEGETABLES: 4 servings per person daily 1 serving daily of Irish or sweet potatoes 1 serving daily of tomatoes or citrus fruits 1 serving daily of leafy green or yellow vegetables 3 to 5 servings a week of other vegetables	3 bu. Irish potatoes 4 bu. sweet potatoes $\frac{1}{2}$ bu. field peas 104 lb. other vegetables (fresh) 36 qt. canned vegetables	15 bu. Irish potatoes 20 bu. sweet potatoes $2\frac{1}{2}$ bu. field peas 520 lb. other vegetables (fresh) 180 qt. canned vegetables	$\frac{1}{4}$ to $\frac{1}{2}$ acre vegetable garden $\frac{1}{4}$ acre Irish potatoes $\frac{1}{4}$ acre sweet potatoes $\frac{1}{2}$ acre field peas
FRUIT: 1 serving daily	83 lb. fruit (fresh or dried) 50 qt. canned fruit	416 lb. fruit (fresh or dried) 250 qt. canned fruit	400 ft. row strawberries 100 ft. row blackberries, if wild, fruit not obtainable 1 acre family orchard, well cared for 10 apple trees in 3 varieties 10 peach trees in 3 varieties; other berries and grapes, if desired
CEREAL FOOD: Daily—bread, cereals, etc.	3.2 bu. wheat 3 bu. corn	16–18 bu. wheat 15 bu. corn	$2\frac{1}{2}$ acres wheat 1 acre corn
SWEETS: 1 serving daily	3 gal. sorghum 40 lb. honey	15 gal. sorghum 200 lb. honey	$\frac{1}{4}$ acre sorghum 4 to 5 colonies or hives of bees

needed to supply farm-grown diet needs, including feed for all horses and mules, ranged from 2.6 acres per capita in South Carolina to 4.1 acres in Texas. The differences between States reflect varying opinions as to what a minimum-adequate diet really is, as well as varying production possibilities for crops and livestock. The pasture acreage included plowable, woodland, and other pasture, exclusive of cropland and free ranges in use for grazing.

Fig. 57. The well-planted garden will provide an ample supply of vegetables throughout the growing season. (*Extension Service, U.S.D.A.*)

The acreage of cropland used for these same purposes in 1937 ranged from 2.0 acres in South Carolina to 3.3 acres in Texas. For the eight States, 21 per cent more crop land and 11 per cent more pasture would be required to supply the diet specifications that were in use in 1937. This increase, 5.8 million acres of cropland, represents 5.9 per cent of all the cropland available.

THE TENNESSEE LIVE-AT-HOME PROGRAM

During the past decade a vigorous program has been carried out by the extension services, farm organizations, and other groups interested in encouraging a live-at-home program to provide an adequate food supply for Tennessee farm families. The recommendations in Table 10 are made in Publication 207 of the University of Tennessee.

FOOD OF FARM FAMILIES—INADEQUATE DIETS[4]

Despite the marked progress of the science of nutrition during the last decades, and the many efforts to spread this knowledge in helping families to

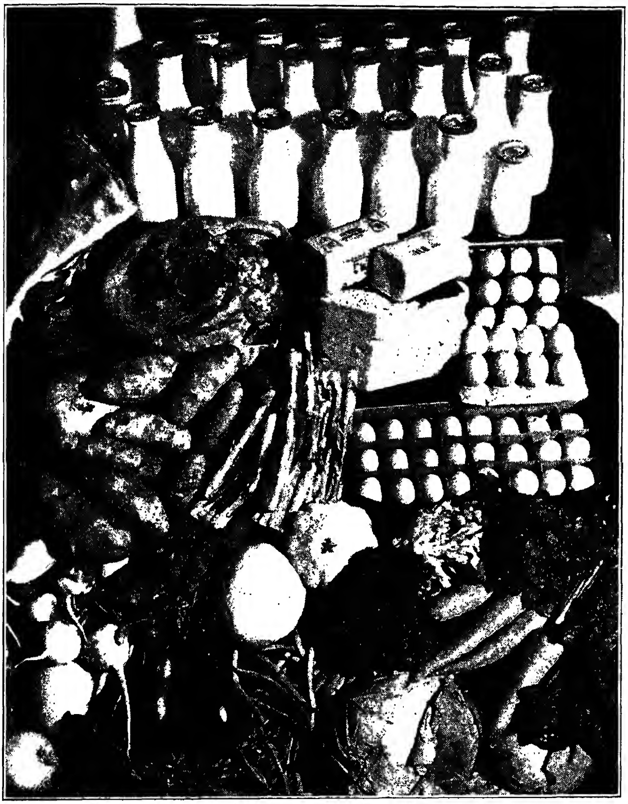

Fig. 58. "Food will win the war and make the peace." Our entry into war against the Axis powers called for our greatest total agricultural production on record. The farmers of the nation enlisted in a war program of greatly increased milk, egg, meat, vegetable, and fruit production. At the same time corn, cotton, and wheat were maintained on a substantial acreage basis. The United States became the larder of the united democracies. (*U.S.D.A.*)

better their diets, recent studies indicate that fewer than half of our nonrelief farm families achieve nutritionally adequate diets—diets that provide a generous margin for safety over minimum requirements. Fully a fourth of these

[4] The Outlook for Farm Family Living in 1941, Bureau of Home Economics, United States Department of Agriculture.

farm families are believed to have diets that are definitely below the safety line.

What does it mean—to say that families have diets that are below the safety line? It does not mean that all persons in these families are hungry, although some of them may be—at least part of the time. Nor do they all have clinical symptoms of pellagra, or beriberi, or scurvy, or other symptoms that would mark advanced stages of malnourishment, although some may. What it means is this—subsistence on poor diets for prolonged periods brings in its train such symptoms as chronic fatigue, lethargy, shifting and variable aches and pains, digestive disorders of certain types, an ill-defined sense of uneasiness or apprehensiveness—symptoms that may not confine a person to his bed, but that may greatly reduce his productiveness and sense of well-being and that may lower his resistance to infection. To every one case of frank deficiency disease, there probably are hundreds of cases of latent or incipient malnutrition.

WHAT A SAILOR EATS

(The Yearly Food Allowance * per Man in the Navy)

Flour	273.7 pounds
Meat, fish or poultry *	456.2 pounds
Fresh vegetables *	1003.7 pounds
Fresh fruit *	365.0 pounds
Beverages:	
Cocoa	44.4 pounds
or Coffee	44.4 pounds
or Tea	11.4 pounds
or Powdered Milk	22.8 pounds
Fresh milk	22.8 gallons
Butter	36.5 pounds
Cereals, rice, or starch food	36.5 pounds
Cheese	11.4 pounds
	36.5 dozen
Lard or lard substitutes	36.5 pounds
Oils, sauces, or vinegar	4.6 gallons
Sugar, soda, salt, flavors, spices, etc.	114.1 pounds

EQUIPMENT AND SPARE CLOTHING PER YEAR

	Average per Soldier	*Normal Average per Person*
RAW WOOL	160 pounds	9 pounds
GINNED COTTON	230 pounds	30 pounds

* The quantities given are for fresh meats, vegetables, and fruits, but in actual service the equivalent in preserved or processed form may be used (U.S.D.A.).

CHAPTER XV

GROWING FEED AND COVER CROPS FOR WILDLIFE

When the first settlers came to America, they found a country of virgin woods and prairies, watered by clear streams. Scattered Indian tribes lived on the game from the forests and the fish from the streams and lakes, and on the corn, beans, and squashes produced in small, temporary patches. The Indians disturbed the soil and the forests but little. Losses from erosion were at a minimum in the timbered and grass-covered, humid area of the Mississippi Valley of the eastern half of the United States. The soil of the short-grass country of the semi-arid Western Plains region and the Northwest was held down by sod centuries old.

The first white settlers who established colonies on the eastern coast and the pioneer wave of trappers, woodsmen, and farmers who moved westward, lived largely on the game and fish of virgin lands. The native wildlife of America's forests and prairies helped build and establish our country. The fish of lakes and streams was an important food in pioneer times. The fur industry sent trappers into new territories, exploring and holding the land for the United States.

As the tide of settlement increased, the forests were cleared, prairies were plowed, marshes and lakes were drained. Market hunters and game hogs had their day—wild game became scarce. The passenger pigeons that darkened the skies during the time of migration in the North Central States were slaughtered by market hunters—the great migration mysteriously ceased. The last survivor died in captivity in the Cincinnati zoo in 1914. The great herds of buffalo that roamed western prairies by the millions were reduced to a few hundred head in national parks by hunters who shot them for their hides during the last quarter of the nineteenth century. Wild geese, swans, and ducks were greatly reduced in number by market hunters and by game hogs. Cities and towns and industries poured pollution into rivers and lakes, and in many streams fish were killed or greatly reduced in number.

Our native wildlife, however, is still a valuable resource. Game from fields and forests and fish from our streams and lakes contribute substantially to our food supply. The bird life of the woods and

fields is recognized as most important in the control of insect pests and weeds. It has been demonstrated that many forms of wildlife, such as quail, rabbits, squirrels, and the small fur-bearing animals, adapt themselves to living with man, particularly in regions of mixed farming where crops are diversified and farm woodlots maintained.

FIG. 59. Increased acreages of soil-conserving crops benefit wildlife by providing increased feed and cover.

The observance of game laws and restriction of bag limits and the protection of breeding and feeding areas is resulting in an increase in many species of wildlife. By protecting woods from fire, providing natural feed plants, and maintaining game laws, deer have been greatly increased in many of our older states. Maintenance of trapping seasons and regulation of the fur harvest have preserved and in many instances increased the supply of fur from muskrats, skunk, raccoon and beaver. The breeding of fur-bearing animals, particularly fox, mink and muskrat, and the breeding of pheasant and quail have become important farm enterprises in many states.

Great industries depend on our wildlife, such as the resort and recreation business, the manufacture and sale of sporting equipment,

outing clothes and camping equipment, and the breeding and training of hunting dogs.

During recent years, interest in the conservation of our wildlife has been awakened and our wildlife resources are now being conserved and increased. The United States government, through the Biological Survey, cooperates with states in establishing laws to pro-

Fig. 60. Quail are readily found in the patch of corn and soybeans grown on a Virginia farm where the training and boarding of hunting dogs is a major source of income.

tect wildlife and to provide sanctuaries and breeding farms. Other governmental agencies, such as the Forest Service, Soil Conservation Service, and the Agricultural Conservation Program of the AAA, contribute to the wildlife-conservation program by encouraging the planting and protection of forests and woodlots, the conservation and improvement of our water supply, and an increase in feed and cover crops not disturbed by the plow or mower.

From eighty to eighty-five per cent of our present game supply comes from land devoted to agricultural use. Farmers on the land are therefore the actual custodians of nearly four-fifths of our wildlife resources. The preservation of wildlife, and its future increase,

will depend upon farming practices employed by the average farmer. The practices that improve conditions for wildlife are the planting and maintenance of farm woodlots and windbreaks, and the planting of cover and feed crops that will provide a feed supply during all months of the year. Many farmers find it profitable to plant feed crops that are left out to provide feed for song birds and wildlife.

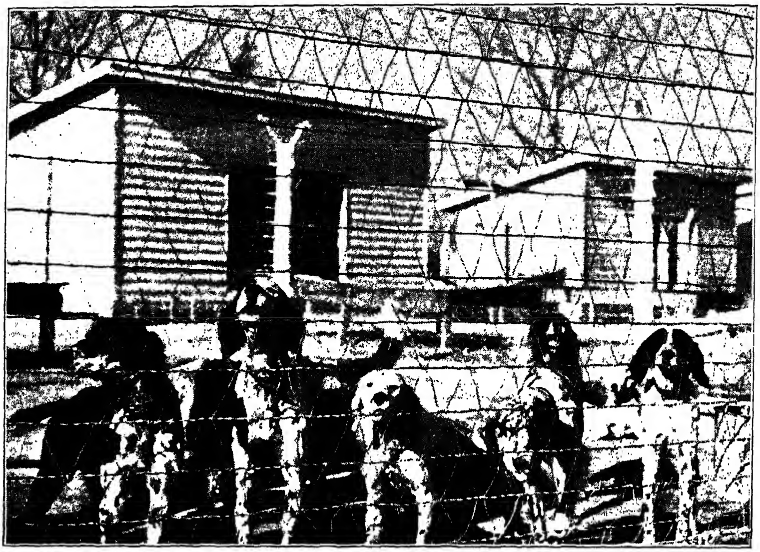

FIG. 61. Large interests depend on the extensive maintenance of wildlife. They include the breeding, training, and care of hunting dogs, the manufacture and sale of clothes and equipment for fishing and hunting, and the feeding and care of sportsmen in the field. (*U.S.D.A.*)

Mixed plantings, including such crops as sorghum, sudan grass, millet, buckwheat, lespedeza, clover, soybeans, and cow peas may be planted in strips along the edges of fields, preferably near the farm woodlot, and if left unharvested the taller growing plants will furnish feed and cover during the period of deep snow. Farm woodlots may be improved by planting nut trees and haw trees and by planting the edges of the woodlot with berries and fruit-bearing shrubs and vines. Ditch banks that cross fields should be covered with grasses, legumes, and shrubs in order to provide protective runways for birds and small animals. The parts of fields adjacent to woods, where cultivated crops fail to produce profitably, can be advantageously planted to lespedeza or winter vetch or to other crops that will provide cover and feed for birds and animals.

Our native wildlife is of interest to town and city people alike. Their cooperation in protecting wildlife, providing feed and cover crops, observing game laws, putting out camp fires, etc., will result in a material increase of our valuable wildlife and fish supplies.

HOW THE AAA HELPS WILDLIFE

Payments are available to farmers for practices that help wildlife conservation under the 1940 Agricultural Conservation Program of the AAA. Some of these practices are as follows:

FIG. 62. A windbreak, bordered by a fringe of low-growing grasses and shrubs, provides feed and protection for wildlife. This strip of land is too near the trees for the efficient production of corn or other cultivated crops. (*AAA*.)

1. Farmers who plant, replant, cultivate, protect, and improve forest trees or mixtures of forest trees and shrubs suitable or beneficial for wildlife or for the protection of wildlife may be paid $3.00 to $7.50 per acre.
2. Farmers who seed permanent grasses or permanent pasture mixtures under AAA specifications may be paid $3.00 per acre.
3. Farmers who establish a permanent vegetative cover by planting crowns of kudzu may receive $6 per acre.
4. Farmers who allow nature to reseed noncrop open pasture by nongrazing during the normal pasture season under AAA specifications may receive $1.50 per acre.

Practices beneficial to wildlife do not stop with farm lands. Under the AAA range program, grass cover is being protected and improved by deferred grazing and reseeding and by improvement of the water supply. In the 17 range States, over a 3-year period, 130,000 acres have been contour furrowed; approximately 2,400 miles of spreader terraces have been constructed; many thousands of spreader dams have been constructed, involving the moving of 5½ million cubic yards of material; and thousands of tanks and reservoirs for water storage have been created, involving excavation of more than 72 million cubic yards of material. Reports show that increased numbers of game animals and wild fowl are receiving benefits from these range-conservation facilities.

The erosion-control practices that regulate the water run-off from watersheds are distinctly improving lakes and streams for fish.

A number of soil-building practices included in the 1940 program provide food and cover, though such practices were not specifically designated for the conservation of wildlife. In addition, the provisions encouraging the establishment of farm wood lots and windbreaks help wildlife. Such wooded areas, usually with a fringe of brush and berry patches bordering on cultivated land, provide protected breeding places and an ideal source of food.

Benefits To Be Derived from Wildlife

Conservation of wildlife has become an important item for consideration in planning the welfare of entire areas. Farmers realize that upon their methods of handling their lands depends, to a great extent, the fate of our national wildlife resource.

Wildlife on the farm provides recreational and other advantages for the farm family. The harvested game is an economical source of food and adds welcome variety to the diet. Then, too, song birds and other nongame species are of great service in controlling insect pests and in destroying weed seeds. Sometimes a considerable income is derived from the catch of fur-bearing animals, and there are occasional opportunities to sell or lease hunting, trapping, and fishing privileges on the well-stocked farm.

FARM FISH PONDS[1]

Stocking

1. As soon as the pond begins to fill, Gambusia minnows should be added at the rate of 100 or more per acre of water. These minnows may be secured from neighbors' ponds or through the County Health Officer. They aid greatly in controlling mosquitoes and are excellent food for bass and crappie.

2. Place several species of fish in the same pond. When a pond is stocked with bream only, as soon as these bream reproduce it becomes so overcrowded that the small fish are unable to grow because of lack of food. If the correct number of bass or crappie are added to the pond containing bream they will feed on the surplus and thus help to prevent overcrowding.

[1] From Handbook of Alabama Agriculture, 1940.

3. Stock an acre of water, if not fertilized, with 400 bream and 50 bass or crappie; if fertilized, with a maximum of 1500 bream and 200 bass or crappie. If it is desired also to add catfish to the pond, the most suitable species appear to be the common bullhead catfish. For each 25 catfish added, reduce the number of bream to be added by 100.

4. Stock with fry or fingerling fish as near the same size as possible. Bass, catfish or crappie should be placed in the pond at the same time as the

FIG. 63. The farm fish pond can be made a source of pleasure and profit and provides water for livestock (Alabama).

bream. This should be done so that all will have an equal start since these young fish compete with each other for food.

5. Much poorer results may be expected if the pond is stocked with a few large brood fish as this usually results in overstocking as soon as these fish have spawned. If this has been done it is often better to drain the pond after spawning and remove all except the correct number of small fish.

Requests for fish for stocking new ponds should be addressed to: Department of Conservation, Montgomery, Alabama.

Rate, Time, and Frequency of Application of Fertilizer

Fertilize each one-acre of water with 100 pounds of 6-8-4 plus 10 pounds of nitrate of soda at each application. Make the first application of fertilizer in the spring as soon as the danger of floods is past (usually April or May).

If the pond has not been previously fertilized, two or three applications should then be made at weekly intervals. After this, an application should be made whenever the water becomes clear (approximately every four weeks). The last application should be made in September, the pond thus receiving from eight to 10 applications per year.

Cost

The cost per acre per year varies from $10 to $14. In small ponds up to several acres in area, apply the fertilizer by walking along the edge of the water and broadcasting towards the deeper water. Make no attempt to completely cover the pond. Apply in the shallow water and wave action gradually spreads it over the entire pond. At the same time take care not to apply any of the fertilizer right at the edge of the water as this will encourage the growth of weeds. It is best applied in water from one to five feet in depth. In large ponds broadcast fertilizer from boats over the area where the water is from one to five feet deep.

FIG. 64. Clear waters that provide good fishing flow through watersheds protected by woods and grass.

Weed Control

The majority of food in the pond is furnished by microscopic plants which float in the water. It has been found possible to raise as high as 580 pounds of fish per acre in ponds which *do not contain* any of the larger water plants

such as water mosses, water lilies and pond weeds. These larger plants are of very little value in ponds and most of them are detrimental. In new ponds pull them out whenever they appear. Most of them are easy to control if not allowed to get thoroughly established. After they are once established it is practically impossible to get rid of them without draining the pond and cultivating the area for one summer.

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CHAPTER XVI

LOOKING FORWARD

Looking ahead into the future should be of particular interest to young people who choose farming, or an occupation related to agriculture, as a profession. They should be interested in speculating on the effect of forces recently developed, and of inventions as yet unheard of, on farming as an industry and as a way of living. Since many of us reasonably may expect to reach the age of seventy, perhaps it will be well worthwhile to attempt to envision America fifty years hence—the kind of farming and the extent of prosperity and happiness among the people of farm and city existent fifty years from now.

Before attempting to look ahead, a look backward over fifty years will prove well worthwhile in causing us to realize the tremendous changes that can occur within a half century. Farmers of 1890 knew nothing of automobiles, tractors, trucks, rubber-tired farm vehicles, baby combines, milk separators, vitamins, hybrid corn, rust-resistant wheats, crop insurance, the telephone, or electricity adapted to many phases of farm use. Airplanes existed only in the minds of dreamers, who were ridiculed by the public generally. Rural delivery of mail was limited, and the Parcel Post Law had not been passed.

Thirty years ago no radios gave forth the daily news, weather reports, enemy attacks, market quotations, etc. A bathtub with running water was a curiosity to most farmers, and when the farmer went to town he generally slept in a boxstall at the livery stable to be near his horses. Contacts of country folks with their neighbors were limited by the difficulty of transportation. Hours were long and the work was hard, and markets limited—and a great majority of farm boys took the advice of Horace Greeley to "Go West, Young Man." County agricultural agents, agricultural courses in high schools, boys' and girls' 4-H club work, county farm bureaus, farm credit associations, cooperative livestock shipping associations, and land-use planning were influences not yet at work in our farm communities. The roads of the time were macadam, gravel, or plain dirt—dusty during the dry weather and often studded with muddy sloughs during rainy seasons.

During the past fifty years remarkable developments have been made in plows, cultivators, and harvesters—all machinery used in preparing and seeding the land and harvesting crops. Combines and tractors have come into general use, and during the past ten years a small, rubber-tired type of tractor has been adopted with remarkable rapidity, further displacing horses and mules. Small combine har-

FIG. 65. The use of rubber tractor tires brought about a reduction in the size and cost of tractors and increased speed and efficiency and flexibility and comfort in tractor operation. Shall we use synthetic or natural rubber in the near future?

vesters have almost replaced the old threshing machines. The time needed to produce an acre of corn has decreased from more than fifty hours to less than twelve. Farm work is almost wholly on a machine basis from the time of planting to harvesting. The market range has been increased to an undreamed-of radius by the general development of hard-surfaced roads, by improved farm-to-market highways, and by the use of trucks and automobiles.

Farm homes are now generally equipped with electricity and electrical home appliances and with telephones and central heating plants. The isolation largely is gone from country living. Physical hardship has been greatly reduced, and country life today offers opportunity for the constructive use of leisure.

During the same time that all these splendid influences are enriching country life, there are areas where the misuse of extractive farming has caused the land to deteriorate, where farm homes have fallen into decay, and the people have abandoned the land. Erosion has injured great tracts of our soil—possibly as much as 50,000,000 acres during the past fifty years. Dust storms, previously unknown in the

FIG. 66. Bibbins Hall of the Grange League Federation, Ithaca, New York, where courses in cooperative objectives and administration are offered to employees and farmer members—a pioneer venture in cooperative education. Does this presage a new educational program for farm cooperatives? (*H. E. Babcock, Director, G. L. F. Institute.*)

eastern part of the United States, swept the country during the droughts of 1934 and 1936. The Ohio and other rivers broke all flood records during 1935 and 1937. Fifty years which have seen so much development, also brought with them much retrogression.

The next fifty years will also see great changes, resulting from inventive genius, providing for the comforts and happiness of farm families; but unless farmers cooperate and governmental policies give support to the adequate conservation of our natural and human resources, the next fifty years can be expected to bring about further deterioration of the land of our great country.

It is hoped that those who read this chapter will envision future developments and write their own forecast. What will be the state of

our land and the farm prosperity if the Agricultural Conservation Program is continued for fifty years with adequate federal support? How many more millions of acres of our land will be made more fertile by the use of lime and phosphate, and how many more millions of acres will be saved from losses by erosion, by the growing of cover crops during the growing season? How many millions of people will be kept happy on the land as the result of this change in

FIG. 67. A significant experiment at the Alabama Experiment Station. Treating fish ponds with lime and fertilizer not only greatly increases the production of fish but also indicates the deficiency of calcium, phosphorus, potash, and nitrogen in soils drained by local streams and the need for applying these elements to nourish adequately the crops, livestock, and human beings that live on these soils.

land use that may be achieved during the next fifty years, as compared to the laissez-faire, exploitive land-use program of the last fifty years?

If the Agricultural Adjustment Administration continues, can farmers universally be educated to the need of cooperating in the control of production and marketing, in order to insure them fair prices for their major commodities? Will war be followed by depression or will American farmers cooperate to insure a period of security and plenty?

What will be the effect of the quick-freeze method of preserving fruits, meat, and fish during the coming fifty years—or will some improved process supplant this revolutionary invention? The entire canning industry of America developed during the last fifty years, so we can expect great changes in the industries that depend on agri-

culture. Nearly all farm families now ride in automobiles, a development that came during the last thirty years. How many farmers will make use of airplanes in shipping the more perishable and valuable products to market, and how many, during the next fifty years, will have their own planes for travel purposes?

Are we entering the plastic age when our houses, furniture, and plumbing fixtures will be made of plastics, some from farm waste?

OUR WAR PROGRAM

With forces of aggression destroying free people in Europe and Asia and threatening our peace and destroying our markets, and with our country at war with the Axis powers, America is engaged in a great war program. Agriculture, industry and labor, capital and business, are all called upon to give their utmost.

As stated by President Roosevelt in his address to Congress after the treacherous Japanese attack on Pearl Harbor, American farmers were in a strongly organized state for war production. Ample supplies of needed foods were available, and the AAA and the ever-normal granary program insured the abundance of wheat, corn, and cotton, fruits and vegetables, meat and milk.

As never before, farmers are organized and in position to cooperate in shaping their productive efforts to meet needs that the future will place upon them. Will the future bring universal farmer cooperation? Farmer-consumer cooperation?

In addition to the Grange, Farm Bureau, Farmers' Union, and the long-established cooperative marketing, livestock shipping associations and creamery associations, new agencies, created within the past eight years, have brought farmers into close cooperation in working out their problems. More than six million of the seven million American farmers were actually engaged in carrying out the Agricultural Adjustment and Conservation Program. The Soil Conservation Service, Farm Credit Administration, Crop Insurance, Rural Electrification Administration, Farm Security Administration, Surplus Marketing Administration, and land-use planning committees are in operation on a nationwide scale. Aiding these agencies in applying them to practical agriculture and in training farm leaders throughout the land, the extension services, land grant colleges, experiment stations, and the United States Department of Agriculture function in all rural communities.

By cooperating in these programs and in new ones that may be necessary to meet future conditions, the farmers of this nation can

build their future on the secure foundation of democratic cooperation. By efficient methods of production and by working together in planned programs of production adjustment, marketing, and conservation, American farmers can render their greatest service in increasing our national strength to preserve peace or to wage war should attacks come.

FIG. 68. Severe drought may cause great loss or failure of cotton, corn, wheat, and other major crops. Will the future bring forth practical and cheap methods of irrigation for use on extensive field crops in our humid areas? (*Crop Insurance Corporation, U.S.D.A.*)

OPINIONS OF LEADING AUTHORITIES ON THE PRESENT AND FUTURE

FARMING AND THE NEW GENERATION[1]

You may wonder why in these hard times for agriculture we should wish our children to become farmers or farmers' wives. May I tell you?

The farmer and his family have more and better food to eat than have most city people, and in times of depression they are more certain of a livelihood—if they have not mortgaged the farm. The farmer has better health than the

[1] Why I Want My Boy to Be a Farmer, by O. E. Baker, Bureau of Agricultural Economics, United States Department of Agriculture.

city man and lives longer—4 or 5 years longer—according to a recent study made by the Metropolitan Life Insurance Co. The farmer becomes a wealthier man than the majority of city men, judging from the per capita wealth of rural and urban states. The farmer is more likely to enjoy his work than are most city people. Most city work is monotonous—tending a machine in a factory, operating a typewriter, standing behind a counter in a retail store hour after hour. The farmer is more likely to rear a family and promote the welfare of the Nation and the race.

DEMOCRACY—A WAY OF LIVING[2]

We think of democracy as the right to speak and write and think and go to church as we please. We think of it also as a form of society where every citizen is entitled to a voice in the affairs of government through his vote and also through the representations of his interest group organization. But our American democracy is more than this. The people who settled this country in the early days and those who have come here through the years have dreamed of America as a land of opportunity for the common man. They have thought of it as a place where their children would have a chance for an education and a job, and where each could be his own boss. That is the American dream and it is at the heart of our democracy. It is an ideal that is unselfish and fine, and, if understood and worked for, it can be far more powerful than the totalitarian ideal.

WEALTH OF THE UNITED STATES—NATURAL, ACQUIRED RESOURCES[3]

Viewed from a world standpoint the United States occupies not more than 6½ per cent of the land surface and contributes a corresponding 6½ per cent of the world population. In area and in people it is about one-fifteenth of the whole. But the United States possesses 45 per cent of the wealth of the world. In its treasury lies 60 per cent of the monetary gold in the possession of mankind. It has 17 billion of the 29 or 30 billions in all the world—20,000 tons of it, enough to load a freight train five miles long.

Every year the world produces, in round figures, 2 billion barrels of oil. Census figures show that of this 2 billion barrels 1¼ billions, or 62 per cent, are produced within the United States. The United States produces one-third of all the world's pig-iron and steel. It mines 35 per cent of the copper and the lead and the zinc; 30 per cent of the world's coal. Inexhaustible sulphur mines skirt the Gulf of Mexico.

[2] "Democracy and Farm Organization," by Secretary Wickard, at Syracuse, New York, Nov. 15, 1940.

[3] "150 Years of Census Taking," Department of Commerce, Bureau of the Census.

There are 43 million automobiles in the world and 29 million of them, 68 per cent, are in the United States. The world has 41 million telephones and 20 million of them are in this country.

In the year 1937 the world produced 35 million bales of cotton. More than half the total, 18 million bales, grew in the United States. In a good year the world produces 5 billion bushels of wheat and the United States comes close

FIG. 69. Corn stored in metal cribs under seal in the "ever-normal granary" program. To what extent may this principle of protecting farmers from the disaster of low prices and of providing the public with ample supplies be applied to other agricultural commodities? (*AAA, U.S.D.A.*)

to one billion, or a fifth of world production. Four out of every 10 boxes of yellow oranges come from the United States, and 9 out of every 10 boxes of grapefruit.

There are more students in the colleges and universities of the United States than in those of all the rest of the world put together. Americans are by far the best educated, best housed, best clothed, best fed people in the world.

A LOOK AHEAD WITH AMERICAN FARMERS[4]

We cannot expect much rapid increase in our foreign markets because war-torn Europe and Japan and China and other countries will not have the

[4] M. L. Wilson, Director of Extension Work, United States Department of Agriculture.

money with which to buy our products. And, when our defense spending, which is largely responsible for increased demand for farm products in this country, slows down, farmers may face another major period of readjustment. For that reason, sound planning with the long-time outlook in mind as well as the immediate future is just good business.

FIG. 70. A strong army requires good food and clothing. What part will American agriculture play in winning and maintaining peace?

Briefly, we have lost most of our foreign markets, which is especially hard on cotton and wheat and tobacco (of which we have surpluses). We can expect defense spending to bring increased demand in this country, which will brighten the immediate outlook for milk, poultry, and eggs, fresh vegetables, and fruits, and pork and beef.

But, while farm prices are increasing, things farmers buy may go up faster than the things farmers sell, and the adjustment that seems probable after the war and when defense spending slows down makes sound planning on a cautious, long-time basis now extremely important to every farmer and farm homemaker.

Sherman E. Johnson has remarked, "As a weapon of war, I seriously doubt that food has an equal."

RECOMMENDATIONS FOR ADJUSTMENTS IN AGRICULTURE MADE NECESSARY BY WORLD WAR II [5]

Adjustments by farmers are bound to be widespread, for all the major commodities will be affected to some extent.

A shift from cotton and tobacco to milk, fruits, and vegetables in the South would make available a much better food income to the undernourished in that region.

A shift from wheat to livestock on the Plains would probably not lower our cereal intake, but add to our meat items and help conserve the soil.

Shifts in the Corn Belt to lean meats, milk, and wool would also meet needs of our conservation work and our national food and fiber budget.

Direct assistance may be required temporarily to assist farmers who shift from cotton, tobacco, wheat, or corn. These shifts will mean increases in dairy and poultry products, meats and wool, fruits and vegetables, and timber products.

The long-time advantage to farm and nonfarm families of these shifts will be evidenced in better living.

Statement by Secretary of Agriculture Wickard "After Pearl Harbor"

The new 1942 goals call for the greatest production in the history of American agriculture, and for putting every acre of land, every hour of labor, and every bit of farm machinery, fertilizer, and other supplies to the use which will best serve the nation's war time needs.

The coming production season is the most crucial in the history of American agriculture. To American farmers, the nation looks for enough production this year to feed and clothe our own people for their war time task. To American farmers, the United Nations look for indispensable supplies of food and fiber for their people and fighting forces. No one can foresee the exact size of the needs of our allies a year from now, but already we know they will be large, and I fear they will be larger than we realize at this time.

Guide to the Future. At the entrance of the Archives Building in the nation's Capitol, this sentence meets the eye:

The past is prologue—study the past.

[5] "Agricultural Situation," Bureau of Agricultural Economics, United States Department of Agriculture, January, 1941, issue.

PART II

CHAPTER XVII

CORN

Corn is grown to some extent in every state of the United States. Under such a diversity of conditions, it is evident that great variations exist in the types of corn produced and in the practices followed in production. The subsequent material is presented with a view to giving some impression of the scope of the variations and also to point out the most common practices used in areas wherein corn is a major crop. There is intent not to present all the minute details of production practices but rather to provide information based, so far as possible, on experimental investigations pertaining to the most important aspects of growing corn.

Climatic Factors in Corn Production. It is an important practice in corn production to use varieties adapted to the climatic factors of temperature and rainfall for the area involved. A suitable variety is one which normally matures before the first killing frosts and yet makes full use of the average length of the growing season and of the usual moisture supplies. The qualities within corn, relating to the length of the growing season, vegetative characteristics, and moisture requirements, are inherited.

The variations in the climatic conditions in Nebraska, for example (154),[1] illustrate the need for giving attention to adapted varieties of corn. The average annual rainfall for Nebraska varies from 32 inches in the southeastern part to 16 inches in the western part. It is also important to note the distribution of rainfall for the year in relation to the growing season. More than 68 per cent of the precipitation in Nebraska occurs during the months of April to August, inclusive. The amount of rainfall in the months of July and August is especially important because of the effect on corn yield.

Temperature conditions are influenced by factors of latitude and altitude. Since in Nebraska the northern and southern borders are

[1] Numbers in parentheses refer to items in Bibliography, pp. 425 ff.

about 200 miles apart, there is considerable variation in temperature, owing to differences in latitude. The altitude ranges from 840 feet in the eastern portion of the state to an extreme of 5340 feet in the western portion of the state. These variations in latitude and altitude result in growing seasons that range from 170 days in southeastern Nebraska to less than 128 days in the northwestern part of the state. The result is that corn which is adapted to western Nebraska conditions must be short-stalked, low-eared, early ripening, and it must bear ears with relatively shallow and flinty kernels. In the eastern part of Nebraska, later maturing, taller growing strains with larger ears and deeper kernels are grown.

In Massachusetts (25) the altitude and nearness to the ocean are the main factors determining the length of growing seasons. Coastal sections are of low altitude and are further modified by tempering winds which tend to lengthen the period between killing frosts, but also tend to lower the summer temperature to a point less effective for early and midseason growth of corn.

The variations in types of corn to meet different conditions within a state are well illustrated by varietal differences found in North Dakota (187). Corn for one region of that state varies in height at maturity from 3 to 5 feet, and the height of ears above the ground varies from 4 to 10 inches. Corn for other regions within the state varies from 6 to 8 feet in height, and the ears are borne 24 to 36 inches above the soil.

In every state where corn growing is important, an attempt has been made to introduce or develop varieties and strains that are suitable. In such states, maps are usually published, showing the corn regions in terms of length of growing season and listing the varieties recommended for each region in relation to the purpose for which the corn is being produced.

Information pertaining to temperature and rainfall records throughout the United States is published as part of the United States Department of Agriculture, Agricultural Statistics, a volume of which is issued each year.

In times of high prices for seed corn that is known to be adapted, growers are tempted to try cheaper seed of unknown quality. It is usually much better to use seed of known characteristics because the better yields will more than pay for the difference in seed cost.

Soil Requirements in Corn Production. The topography of the land that is used in corn production is most suitable when it facilitates the use of the necessary machinery for economical corn pro-

duction and when it also provides conditions favoring soil-conservation practices. Since corn is an intertilled crop, large soil losses may occur unless the land on which the corn is being grown is level enough to prevent washing or is adapted to the use of economical soil-erosion-control practices.

Although corn is relatively low in its water requirements per unit of dry matter produced, the large tonnage yields per acre and the rapidity with which the growth is made during certain periods result

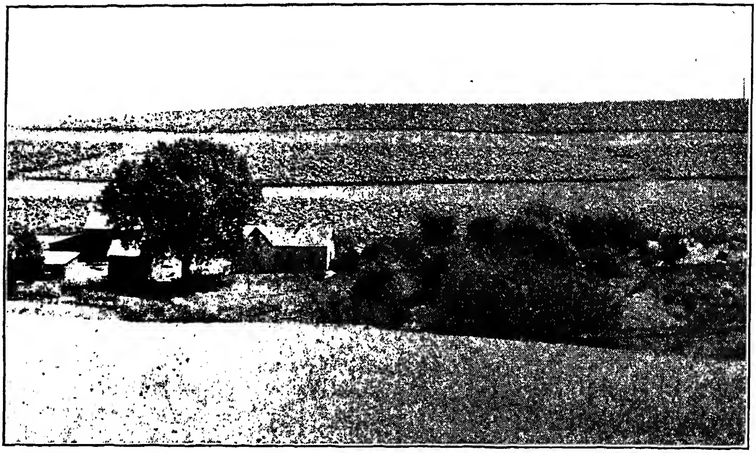


Fig. 71. Corn on an Iowa farm, grown in rotation with small grains, alfalfa, and other crops. (*U.S.D.A.*)

in heavy demands for moisture. During the period of its most rapid growth, corn probably requires more moisture than any other crop. Soils having a high water-holding capacity are essential for corn production. A soil well adapted to corn, however, must be well drained because corn is very sensitive to deficient air supplies in the soil. Such a deficiency often occurs in soils that are poorly drained.

As to soil acidity, corn may be grown over a rather wide range of soil reactions, varying from a *p*H of 5 to 8 (178). At the Ohio Station (56) it has been found that corn in rotation yields best at *p*H 6.8 which is practically the point of neutrality.

A soil that contains large supplies of available plant nutrients is essential for profitable corn production. If natural supplies are not present in sufficient quantity, quality, and balance, much may be done to adjust the conditions, assuming that good conditions of tilth, moisture, and aeration may be established in the soil concerned.

Later material in this chapter on corn-fertility requirements presents further information concerning this point.

The essential soil conditions for corn production are well illustrated by the Prairie soils (178), which extend from western Indiana to eastern Nebraska. This area is the well-known Corn Belt in which the soil conditions, combined with climatic factors, greatly favor corn production. These soils are characterized by dark-brown to nearly black, mildly acid surface soils, underlain by brown, well-oxidized subsoils.

The Tama and Marshall soils found in the Corn Belt rank among the best soils for corn production to be found in the United States. These soils are undulating to gently rolling, mellow, dark-colored silt loams that are well drained. Both soil and subsoil are loose and friable. These soils are loessial in origin and cover large areas in Iowa, Illinois, Missouri, Nebraska, southern Wisconsin, and southeastern Minnesota. Such soils require particular attention to prevent erosion when used for cultivated crops.

Corn in Crop Rotations. When corn is grown continuously upon the same land, a marked decrease in yields occurs, accompanied by a loss of organic matter in the soil. Under such a system, the decrease in plant nutrients, the increase of poor soil conditions, and the increase of disease, insect, and weed problems all serve to reduce yields. At the Missouri Station (178), in a thirty-year experiment in which no manure or fertilizer was used, the yields of corn in a rotation with oats, wheat, and clover averaged 39 bushels per acre as compared to 21 bushels per acre for continuous corn.

On the Morrow field plots at the Illinois Station (178), the yields of corn on land which produced about 55 bushels per acre in the year 1888, dropped to an average yield of less than 24 bushels per acre for the years 1923 to 1932, when corn was grown continuously. Even a poor rotation of corn and oats produced a much higher average yield throughout the period, while a rotation of corn, oats, and clover maintained the yields of corn for most of the period above 48 bushels per acre and above 40 bushels per acre for the whole period.

At the Ohio Station (56), it was found that corn in continuous culture resulted at the end of twenty-one years in a 39 per cent loss of soil nitrogen, owing to the destruction of soil organic matter.

In Missouri Station investigations (178), it was found that an annual average of fourteen years of measurements amounted to 19.7 tons of soil loss per acre and a 29 per cent run-off of rainfall for a system of continuous corn. A rotation of corn, wheat, and clover

reduced the soil loss to an annual average of 2.7 tons per acre, and the percentage of rainfall run-off to 14 per cent.

Under most conditions corn should be grown in a rotation because of the following advantages.

1. Corn can be grown as a part of a diversified crop system which has many advantages from a farm management standpoint.
2. The corn crop benefits from the better soil and fertility conditions which can be maintained by using a rotation.
3. There is a better opportunity to control certain corn insects, diseases, and weeds if corn is grown in rotation.
4. Erosion, involving land on which corn is grown, can be controlled to a greater extent if corn is grown in rotation rather than continuously.

Rotations of corn, wheat, and clover, or of corn, oats, and clover, are the most common in the Corn Belt. Rotations which include two years of corn either with wheat and clover or with oats and clover are also very common. Rotations including corn, oats, wheat, and clover are also rather common. Soybeans have been introduced into many Corn Belt rotations, resulting in rotation systems of corn, soybeans, wheat or oats, and clover.

Corn Fertility Requirements and Practices. As previously pointed out, corn yields are usually best on soils that are about neutral in acidity. The value of using lime and fertilizer on soils that need lime is well illustrated by results at the Ohio Station (56). The average yields of corn per acre for the period 1917 to 1931 were 7.7 bushels on unfertilized, unlimed plots as compared to 24.9 bushels on unfertilized, limed plots. On fertilized, unlimed plots, the average yield was 23.6 bushels, while on the plots which were both fertilized and limed, the yield was 45.8 bushels.

The value of manure and fertilizers in corn production may be judged by examining Table 11. A study of the table will reveal that additional supplies of plant nutrients tend to decrease the time required for corn to reach maturity, reduce the moisture content at husking time, reduce the amount of low grade corn, and increase the yields.

While farm manure does not rank very high in plant nutritive content, containing on the average but 10 pounds of nitrogen, 5 pounds of phosphorus, and 10 pounds of potassium per ton, yet these materials are of direct value in corn production. In addition, the corn crop derives indirect benefits from the use of manure because the

TABLE 11 *

FERTILIZERS SPEED GROWTH, INCREASE QUALITY, AND INCREASE YIELD OF CORN
(Results of Fertility Treatment on Burr Leaming Corn at Wooster, Ohio, in 1927)

Treatment per Acre	Planted May 13				Planted June 3			
	Days planting to silking	Moisture at husking, %	Nubbin, %	Yield (15.5 % moisture)	Days planting to silking	Moisture at husking, %	Nubbin, %	Yield (15.5 % moisture)
None	117	48.3	71	17.7	110	69.1	76	5.5
Manure, 8 tons, 225 lb. 16% superphosphate broadcast	104	46.7	38	45.2	97	53.4	55	31.9
Same plus 100 lb. 3–12–4 in hill	99	37.9	37	55.9	93	50.7	42	33.3
Same plus 200 lb. 3–12–4 in hill	93	33.5	21	70.3	88	50.0	18	47.9
Same plus 400 lb. 3–12–4 in hill	90	31.4	12	80.6	86	46.0	19	56.9

* Ohio Agricultural Experiment Station, Bimonthly Bulletin 132.

humus content of the soil is increased. An increase in humus improves soil tilth, increases the water-holding capacity of the soil, has a beneficial effect upon soil air and temperature conditions, and increases the action of organisms which effect the availability of plant nutrients.

The ordinary rate of application of manure seems to be about 8 tons per acre. Larger or smaller amounts of manure may be used to meet particular needs.

Reports from the Tennessee Station (106) indicate decided gains in corn yields from the use of manure on poor soils. Six tons of manure were applied in each of the years 1906, 1908, 1910, 1913, and 1916. The average yield of corn (grown continuously) for the period 1906 to 1916 was 38 bushels for manured plots and 22.4 for unmanured plots. In a five-year rotation of corn, soybeans, wheat, clover, and grass on fertile soils at the Knoxville Station, the upland manured plots (manure applied at the rate of 15 tons per acre) produced an average of 60.2 bushels of corn for the period 1905 to 1929, while unmanured plots averaged 49.6 bushels. On bottomland at the same station the results were 82.2 bushels for the manured plots and 77.2 for unmanured plots. During the period 1910 to 1930 at the West Tennessee Station, manured plots, on which corn was grown continuously, produced 43.3 bushels as an average, while unmanured plots produced 27 bushels of grain. Manure in combination with fertilizers in the row or hill usually produces the best results so far as corn is concerned.

The use of fertilizers for corn may be judged somewhat from a study of Table 12.

TABLE 12 *

MOST COMMONLY USED GRADES AND AMOUNTS OF FERTILIZER FOR CORN IN STATES CONSUMING 75 PER CENT OF THE TOTAL FERTILIZER TONNAGE

State	Grade	Application per Acre
		(Pounds)
Alabama	3–8–5	100
Florida	4–8–4	200
Georgia	3–9–3	200
Indiana	2–12–6	125
Maryland	2–12–4	100
Mississippi	4–8–4	150
North Carolina	3–8–3	200
New York	4–12–4	300
Ohio	2–12–6	125
Pennsylvania	2–8–5	200
South Carolina	3–8–3	200
Virginia	3–8–3	200
Maine	3–10–6	600

* Adapted from Table 6, page 539, Yearbook of Agriculture, 1938.

As might be expected, there is a great variation in the fertility needs for corn as a result of the wide variation in soil types upon which corn is grown. It is essential to use sources of information for fertilizer recommendations that apply to the particular areas concerned.

When corn is grown in rotation, the question arises as to the application of the fertilizer to the different crops in the rotation. At the Ohio Station (56), it was found, when using a rotation including corn, oats, wheat, and clover, that nearly maximum returns were obtained from applying all the fertilizer to the wheat crop. Conclusions from the experiment were to the effect that a moderate application in the hill or row for corn, combined with a generous application on wheat, was the best system of fertilizing such a rotation.

The question also arises in corn production as to whether the fertilizer should be placed in the hill or row or whether it should be broadcast. In an Ohio experiment (56), it was found that hill applications were more effective than broadcast applications in hastening the early growth of the plants. Such early growth is an advantage

in getting ahead of weeds and possibly in resisting the attacks of insects. Earlier maturity results from hill applications, thus reducing the danger of frost damage. In the case of the soil on which the experiment was conducted, the hill applications were much more effective in increasing yields than were the broadcast applications. Broadcast applications supplementing the hill applications in this instance did not increase the yields sufficiently to pay the cost of the additional fertilizer.

In another Ohio experiment (56), 100 pounds of 3-12-4 fertilizer in the hill, supplemented with 200 pounds of the same fertilizer broadcast, were found to be the most profitable. A split application like this one was found to be more profitable than the hill application alone, and it is clearly demonstrated that there is a particular advantage in putting at least part of the fertilizer in the hill.

The results of such applications are well summarized in Table 13.

TABLE 13

EFFECTS ON CORN YIELD OF VARYING PROPORTIONS OF FERTILIZER APPLIED IN THE HILL AND BROADCAST *

Plot No.	Proportion of Fertilizer (500 Pounds 4–12–4) Applied in Hill †	Height of Corn at 8 Weeks	Planting to Silking	Moisture at Husking	Yield ‡	Increase Over Unfertilized ‡
	(Percentage)	(Inches)	(Days)	(Percentage)	(Bushels)	(Bushels)
1	0	19.8	89	41.3	31.5	6.7
2	25	29.8	86	38.5	40.8	16.7
3	50	31.4	86	38.6	42.1	19.2
4	75	34.1	85	38.4	45.7	22.9
5	100	32.7	84	39.4	42.3	18.9
Check §		14.8	92	45.1	24.6	

* Ohio Agricultural Experiment Station, Canfield silt loam, four-year average.

† Fertilizer applied in hill, mixed with soil to depth of $1\frac{1}{2}$ inches over area 3 by 10 inches. Remainder broadcast.

‡ On basis of 15 per cent moisture.

§ Unfertilized.

In the hill or row application of fertilizer to corn, it is very important to see that the placement of the material is made in a manner that will prevent damage. Trouble results from seeds or seedlings coming in contact with the fertilizer or soil solutions that carry

concentrations of fertilizer salts high enough to impair germination and to damage seedlings.

According to the National Joint Committee on Fertilizer Application, as reported in the Yearbook on Agriculture, 1938, it is generally superior to make hill or row applications of fertilizer to corn, rather than to broadcast the material. It is recommended that hill applications be made in two bands, 6 to 8 inches long, on each side of the seed, but separated from the seed by ½ to 1 inch of soil. The depth of the fertilizer bands may vary from 1 inch below the seed level to slightly above the seed level. Continuous bands are used when corn is drilled.

Data from Table 14 indicate the importance of having corn planters equipped with fertilizer depositors which will place the material in an appropriate position for securing maximum results.

TABLE 14 *

EFFECT OF IMPROVING THE DESIGN OF THE FERTILIZER DEPOSITOR UPON THE RESULTS OBTAINED WITH A SINGLE MAKE OF CORN PLANTER

Amount of 14–12–4 Fertilizer, All in Hill	Increase in Yield over Unfertilized			
	Old-type depositor †		Improved depositor, ‡ bands at side of seed	
	Fertilizer in Contact with Seed, 1929	Fertilizer Midway between Hills, 1930	1931	1932
(Pounds)	(Bushels)	(Bushels)	(Bushels)	(Bushels)
100	−1.7	0.4	11.1	
200	−2.3	−2.4	16.9	19.9 §
300	−18.0	−0.1	13.9	28.8
400	−29.1	−3.7	21.4	

* Ohio Agricultural Experiment Station, Special Circular 53, 1938.
† No deflector or hood.
‡ Deflector and hood.
§ On this plot, 150 pounds per acre.

Corn production is greatly influenced by the use of legumes in the rotation and by the use of legume crops turned under as green manures.

The turning under of winter legumes (178) in Georgia, Mississippi, South Carolina, and Virginia experiments have increased corn yields from 24 to 78 per cent.

In Virginia, the regular turning under of crimson clover improved the land so much in five years that corn yields amounted to 50 bushels per acre per year as compared to 15- to 18-bushel yields once in three years before the clover was used as a green manure.

A 58 per cent increase in corn yields in Alabama occurred when velvet beans were turned under. When the turning under of velvet beans was supplemented with 100 pounds of superphosphate per acre, the yield was increased more than 90 per cent.

The turning under of sweet clover is an effective means of increasing yields of corn in the Corn Belt. At the Iowa station (178), this practice increased corn yields 17 per cent, while in Illinois, results showed yields 17, 37, and 52 per cent greater than adjoining plots on which the clover was not turned under.

Seed Corn. The rapid introduction of hybrid corn has brought about a change in the seed-procurement practices of many corn growers. The problem confronting the general corn grower, desiring to use hybrid seed, is to select a reputable grower who has the type of hybrid seed corn for sale that is suitable for the conditions with which the grower is confronted. While the price per bushel for suitable hybrid seed corn may seem high, yet the per acre cost for seed may be lower than the seed cost per acre for other crops.

The essential qualifications to be kept in mind concerning hybrid seed corn are whether the particular seed in question is suitable for the conditions under which it is to be grown, whether it has been produced in an acceptable manner from the standpoint of preserving the essential qualities to be desired in hybrid seed, whether it shows a high germination test, and whether it has been carefully graded to facilitate planting.

Once a suitable hybrid has been selected, it is possible to secure seed with identical characteristics year after year, providing the growers of the particular hybrid seed maintain their standards of production.

Kiesselbach of the Nebraska Station (76) points out, with respect to open-pollinated seed corn, that it is very important to use adapted seed, bearing the heritable characteristics which make it suitable to the soil and climate where it is being grown. Suitable home-grown seed should usually be given preference although it is possible to

introduce seed from a distance if extreme care is exercised in selection. New seed corn is preferred to old seed, but seed to four years of age may be used. It is important when using either new or old seed to make thorough germination tests. Kiesselbach indicates further that sound, viable seed of good genetic stock may be used

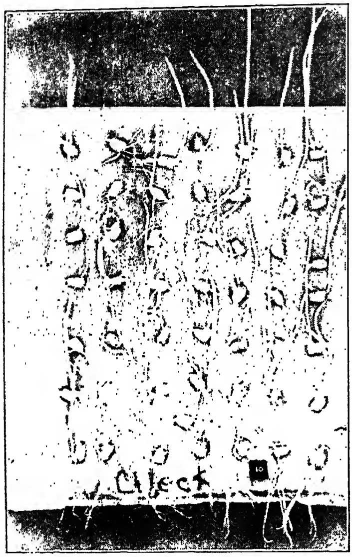


FIG. 72. A test of seed corn which indicates high germinating ability. (*Ohio Agricultural Extension Service.*)

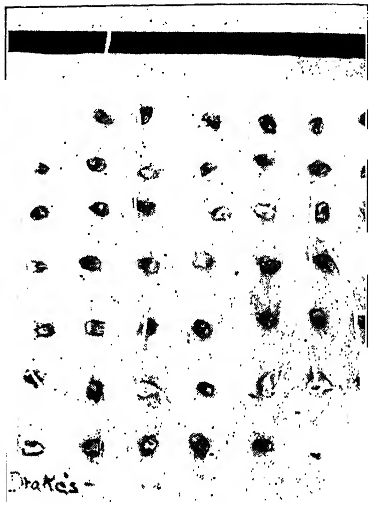


FIG. 73. A test of seed corn showing a high percentage of dead kernels and of kernels with weak germination. Such seed corn should be discarded. (*Ohio Agricultural Extension Service.*)

even if stunted or impaired in normal growth and maturity because of adverse environmental conditions.

If a plan of using home-grown seed of open-pollinated varieties is used, the following steps are essential.

1. Gather the seed in the field so that the production conditions and characteristics may be evaluated.
2. Select ears which have matured within the period of the usual growing season. If the earliest matured years are selected, earliness may be secured at the expense of yield.
3. Select seed corn before severe frosts may have a chance to damage the vitality of the seed.

4. Select ears from vigorous, well-rooted stalks that show no sign of disease or other weaknesses.

5. Select ears which exhibit the characteristics of the variety both as to stalk and ear.

6. Gather two or three times as many ears as will be needed so that further selection may be made after the ears are cured.

7. Immediately after picking seed corn, hang the ears, in the place where they are to be cured, in such a manner that air may circulate about each ear.

8. Seed corn, as gathered in the field, usually contains 20 to 30 per cent moisture. Within a period of two or three weeks the moisture content should be reduced to 12 or 13 per cent. Small amounts of corn may be cured properly in attics that have good ventilation or in a room that has a chimney from stoves in use. Seed corn may be "kiln-dried" if the corn can be stored under conditions where artificial heat may be used in the drying process.

9. After corn has been reduced to 12 per cent moisture it may be stored in a dry, well-ventilated place, protected from extreme low temperatures. If the ears are solid and cannot be twisted and the kernels are hard, it may be assumed that the corn is dry enough to store.

10. Select the ears to be used for seed from the stored stock.

11. Test a general sample for germination. If the germination indicates the presence of many weak ears, use an every-ear test as a means of selecting the strongest seed.

12. Shell the seed ears and grade the shelled corn to facilitate planting.

Seed Bed Preparation for Corn. The seed bed for corn is usually prepared by turning the soil with an ordinary moldboard plow. Other methods of basic preparation of the seed bed seem to have little or no effect in improving yields (178). At the Ohio Station (56), it was found that ordinary plowing to a depth of 7½ inches resulted in yields as large as when the depth of plowing was increased to as much as 15 inches. Results at the Nebraska Station (77) warrant a conclusion that plowing beyond a depth of 7 inches is impractical.

As to time of plowing, it was found at the Nebraska Station (77) that early spring plowing to a depth of 7 inches yielded an average of 18 per cent more than fall plowing at the same depth. In general, the evidence indicates that early spring plowing is the most effective in promoting the best yields of corn. Various production factors may combine to make it advisable to plow land in the fall, but in general

it may be expected that early spring plowing will result in the best yields.

In many regions wherein rainfall is rather short for corn production and there is danger of soil blowing, the ground is often listed in preparation for corn planting. A lister is a double moldboard, plow-like machine which throws a furrow slice each way leaving a furrow with a ridge on either side. When land is single listed, the soil under

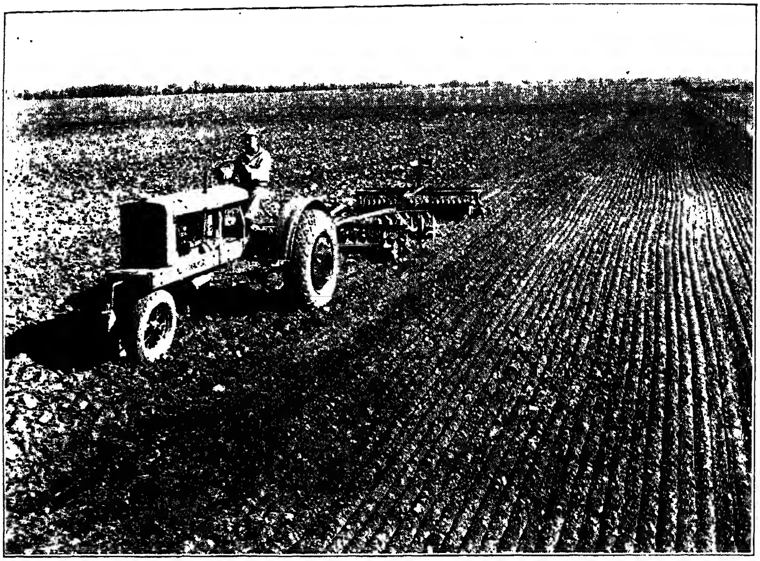


FIG. 74. A well-prepared seed bed is an essential in corn production. (*J. C. Allen and Son, West Lafayette, Indiana.*)

the ridges is undisturbed. In double listing, the lister is used in splitting the ridges left from single listing.

According to results in Nebraska (154), listing may be expected to increase corn yields in central and western sections of that state. At the North Platte Station, listed corn outyielded surface-planted corn by as much as 20 per cent. Results also indicate that on rolling land, unless care is taken to list across the slope, listed fields tend to wash badly, thus reducing the stand of corn. On level lands, listed fields tend to drown out somewhat more often.

After plowing land to be planted in corn, the usual practice is to use a disk harrow, followed by a spike-tooth harrow. The object in these operations is to compact the seed bed, break up large clods, reduce irregularities in the surface of the soil and above all, to de-

stroy all weed growth up to the time of planting. If the land is infested with Canadian thistle or quackgrass, it is usually better to use a spring-tooth harrow or a field cultivator with sweeps or duck-foot shovels instead of a disk harrow, since the action of these machines tends to drag the root and underground stem growth of such plants to the surface.

Corn Planting. The time of planting corn varies according to the climatic factors involved. The Nebraska Station (77) results on time of planting tests, ranging from April 25 to June 14, over a twelve-year period, fail to show consistent superiority for any given date of planting. There was a tendency for either the early or the late-planted corn to yield the highest, but on the average, corn planted on intermediate dates yielded practically the same.

According to the Ohio Station (56) at Wooster, a twenty-year test with the variety Clarage indicated that when the date of planting approximated April 29, the yield of shelled corn was 61.6 bushels. Results from other plantings were as follows: 65.2 bushels for May 7; 63.7 bushels for May 17; 57.8 bushels for May 27; 46.3 bushels for June 6; 37.3 bushels for June 13.

As to the rate of planting it was found at the Ohio Station (56) that a stand of four plants per hill, spaced 3½ feet by 3½ feet, gave the highest average yield of shelled corn per acre from both ears and nubbins. In good seasons five plants gave the greatest yields, and in poor seasons three plants per hill gave the best results. It was found that three plants per hill gave the highest twenty-one-year-average yield of sorted ears. In good seasons more sorted ears per acre were obtained from the rate of four plants per hill. It was also observed that the amount and percentage of nubbins increased as the stand increased.

Investigations at the Nebraska Station (77) indicated that the most productive listing and surface-planting practices yielded essentially alike. Time-of-planting tests in Nebraska, ranging from April 25 to June 14, for a twelve-year period did not indicate a consistent superiority in yields for any date. Under conditions in eastern Nebraska, it was found that an average stand of 2½ to 3 plants in hills 42 inches apart, or the equivalent in drilled corn, was most practical.

Cultivation of Corn. The chief purpose of cultivating corn is to prevent the growth of weeds. This is well illustrated by the data found in Table 15.

TABLE 15 *

THE RELATION OF MANNER AND FREQUENCY OF CULTIVATIONS TO YIELD—SIX-YEAR AVERAGE

Treatment	Average Yield of Shelled Corn per Acre
	(Bushels)
No cultivation, weeds allowed to grow	7.1
Scraped to control weeds	35.1
3 normal cultivations	35.9
4 normal cultivations	37.2
4 normal cultivations and 2 later cultivations	35.2

* Nebraska Experiment Station.

In work carried on at the Ohio Station (56) at Columbus, it was concluded that on black soils with a high organic-matter content (such as the Brookston silty clay loam) it is desirable to cultivate only when weed growth makes it essential. On light-colored soils with low organic-matter content, such as the Miami silty clay loam, it was found that stirring the soil to a medium depth had beneficial results other than killing weeds.

In soils of a compact nature, the root development of corn may be inhibited by a lack of air. Under certain conditions the aeration of the soil may be an essential benefit to be derived from cultivation.

As indicated in Table 15 and according to investigations of a number of experiment stations, there is little or nothing to be gained by extra cultivations of corn, carried on beyond the usual time of discontinuing cultivation. Extra cultivations in some investigations have resulted in slightly lower yields. The ordinary practice of cultivating corn to a depth of 2 to 3 inches produced the best results.

Harvesting of Corn. Over large portions of the Corn Belt, the common practice is to husk corn by hand from the standing stalk. Corn-picking machines are coming into common use, depending somewhat on the factors of prices for corn and the cost of labor for hand picking. Nebraska records (154) indicate that on the average for an entire season, two-row pickers cover about 1.6 acres per hour, while single-row pickers husk 0.9 acre per hour. Hybrid-corn types are being developed which are particularly adapted to mechanical

corn pickers. These machines operate best in stands of corn which are stiff-stalked and uniform in plant characteristics.

Corn is often cut with a binder when it is to be shocked in the field and when it is to be husked from the shock. In regions where corn is grown in a rotation with winter wheat or rye, the corn is cut and shocked, and the soil around and between the shocks is prepared and planted to the grain. Corn may be cut and shocked by hand when the price of labor warrants such a practice.

The corn binder is usually used when corn is cut for purposes of ensiling. At the Minnesota Station (145), tests have been conducted with a field-ensilage harvester. This machine is essentially a combination of corn binder and silo filler. As the machine is drawn in the field, the corn is cut into lengths suitable for ensilage and is elevated into a wagon, which, when loaded, is hauled to the silo where the material is put into the silo with a blower or elevator. According to the Minnesota investigations, the labor costs are somewhat less with the field-ensilage-harvester method of filling silos than with the stationary silo-filler method. Power and machinery costs tend to remain about the same.

Corn is frequently harvested by turning in hogs to eat the corn from the stalks in the field.

Storage of Corn. When ear corn has a moisture content of 30 per cent or less, it may be put in well-constructed cribs for further drying. The object of cribbing is to provide rather free circulation of air through the stored corn to remove excess moisture and to protect the corn from weather and rodents. Cribs should have slatted sides and should be about 8 feet in width. If the corn is unusually high in moisture content when cribbed, various forms of ventilating stacks may be installed within the crib to provide additional ventilation. Corn may be shelled and stored when its moisture content is not over 13.5 per cent.

According to the Illinois Station, the average shrinkage of ear corn by months in percentages is approximately as follows: November, 1.3; December, 3.3; January, 4.2; February, 5.5; March, 7.0; April, 10.0; May, 13.1; June, 15.3; July, 16.2; August, 16.6; September, 16.4; October, 16.5; November, 16.3.

Corn Insects. A number of insects must be considered in connection with corn production. For detailed information concerning these insects and their control consult reference (100).

1. Grasshoppers. Grasshoppers usually lay their eggs in uncultivated ground. Upon hatching in the spring, the young insects eat

numerous crops. Corn may be attacked and greatly injured or even destroyed, if the grasshoppers occur in large numbers.

Grasshoppers may be eradicated to some extent by plowing and discing to destroy the eggs. The common method of control is to spread poison baits where the insects will consume enough to kill them.

2. Armyworms. Partly grown armyworms, living over winter, mature, pupate, and emerge as moths relatively early in the spring. The young worms, hatching from the eggs laid by the moths, attack corn and other crops. A second generation may be destructive in the fall.

Armyworms usually originate in grasses or small grains, and when discovered in large numbers poison bait should be used.

3. Cutworms. There are numerous types of cutworms, some of which, for example, work at the surface of the soil, cutting off young corn plants. Another type works below the surface of the soil on roots and underground portions of the stem. Another climbs plants to secure food, while still another common form migrates in hordes when food supplies become exhausted. The armyworm is a form of cutworm. Poison baits may be used to control the types that work above ground. If corn is to be grown on sod land, it is well to plow early in the fall, as one means of preventing damage from these insects.

4. Chinch Bugs. Adult chinch bugs live over winter in grass, stubble, and in the vegetation along fence rows and roadsides. During the warm days of spring, the adults usually fly to grain fields where they mate and lay eggs. When the eggs hatch, the young suck the sap of growing grass plants. Winter wheat and other small grains may mature before the insects have reached maturity and the flying stage. The immature, wingless bugs crawl from such areas to corn fields or to other fields in which grass or grass crops are growing.

One method of control is to bar their progress and to trap the insects as they attempt to move from a field. Creosote, tar paper, and other barriers are often used. Post holes, dug along the barrier lines, serve to entrap the insects.

5. European Corn Borers. The corn borer lives over winter as a full-grown worm in the stems of whatever plant it has been feeding upon. In the spring, cocoons are formed and moths begin to emerge during June. The moths lay large numbers of eggs on the undersides of corn leaves or the leaves of other plants upon which they feed. On corn plants, the young worms that are hatched from the eggs feed

in protected places about the plant. When about half grown, the worms enter the stalks, ears, or other portions of the plant as borers.

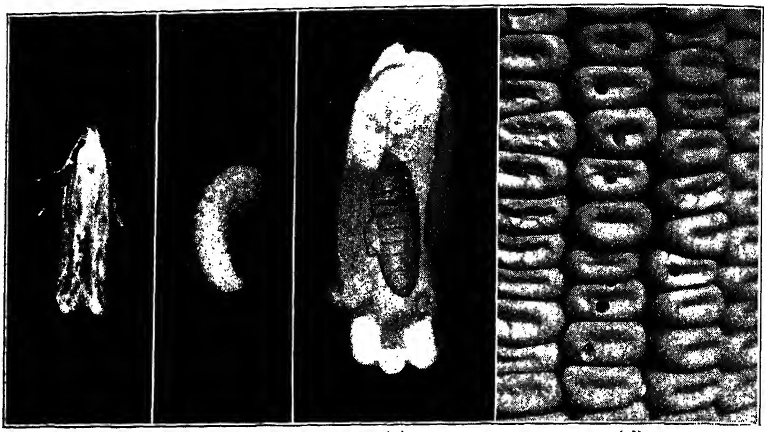
Control consists primarily in the complete use or destruction of the plant material infested with the insects. The thorough plowing under of stubble and refuse is important. Any refuse material containing borers will serve to spread the insect.

FIG. 75. Immature, wingless chinch bugs may be prevented from crawling from a field of small grain into a corn field by erecting a barrier of tar paper. The hole serves to entrap the insects. (*Ohio Agricultural Extension Service.*)

6. Corn Earworms. The corn earworm is very troublesome in that it attacks the ears and destroys the kernels of grain. The insect lives over winter in the soil in pupa form. In the spring, moths emerge and lay eggs on various plant materials. Young corn silk seems particularly attractive. The eggs laid on corn silk hatch in a few days. The worms feed first on the silk and then on the kernels of the ear, particularly the tip kernels.

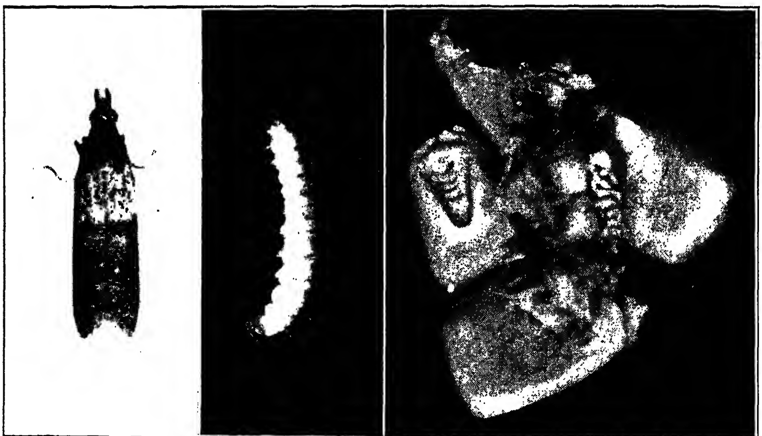
No large-scale method of control has been discovered. Sweet-corn growers sometimes put mineral oil or other substances on the silks at the tips of ears and secure partial control through such practices.

7. Miscellaneous Insects. Growing corn is also attacked by corn root aphids, the grubs of June beetles, wireworms, and numerous other insects.



(a) (b) (c) (d)

Fig. 76. The Angoumois grain moth is very destructive to stored corn. (a) Adult, mottled gray, ¼ inch to ⅓ inch long. (b) Larva, feeding stage, gray to white, to ⅓ inch long. (c) Pupa, changing stage in corn kernel, light brown. (d) Damage, typical exit holes in corn kernel. (*Illinois Agricultural Experiment Station and Agricultural Extension Service.*)



(a) (b) (c)

Fig. 77. The Indian meal moth is a destructive pest of all kinds of stored grains as well as of many other food products. (a) Adult, light brown, banded with chocolate, ⅓ inch to ½ inch long. (b) Larva, feeding stage white to pink, to ½ inch long. (c) Damage, typical webbing in corn kernels. (*Illinois Agricultural Experiment Station and Agricultural Extension Service.*)

8. Angoumois Grain Moths. The angoumois grain moth is very destructive to corn in storage. The adult is a small moth which lays eggs on the grains on which the larvae feed. The young worms burrow into the starchy part of the grain kernels. Fumigants, such as carbon bisulphide, may be used to destroy the insect.

9. Granary Weevils and Indian-Meal Moths. Granary weevils and the Indian-meal moth also destroy stored corn and may be controlled by fumigation.

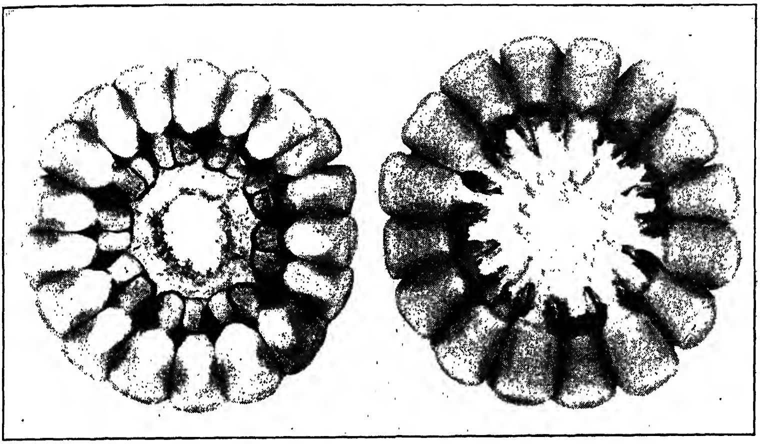


FIG. 78. A healthy ear of corn when broken (right) shows a bright, plump condition, whereas a diseased ear (left) presents a dark, shrunken condition. (*Ohio Agricultural Extension Service.*)

Corn Diseases. A vast amount of corn is destroyed each year through the ravages of corn diseases. Stunted growth, barren stalks, broken-down plants, and diseased covered portions of corn plants are not difficult to find in most corn fields.

From Illinois investigations (82), it has been demonstrated that the losses from corn diseases may be reduced by selection and breeding. Through a five-year period an "old type" of corn, somewhat larger in ear diameter, with a rather rough indentation and a starchy endosperm, yielded 41.7 bushels of corn and had 11.6 per cent commercial damage from rot. This may be compared with a selected corn variety, improved Reid yellow dent, which yielded 46.6 bushels per acre and had 7.3 per cent commercial damage from rot. Illinois Hybrid 172 gave still better results in yielding 55.7 bushels per acre and having only 3.4 per cent commercial damage from rot, as an average for the same period of time.

Many corn diseases attack the plants in the seedling stage. This results in poor stands, blighted and weak plants. Ear-rot fungi, such as *Diplodia,* cause trouble if the kernels used for seed are infected. Infections of various types enter the seed if the seed coat is broken.

The ears of corn are susceptible to numerous diseases. The *Diplodia* organism produces a white moldlike growth which passes through the ear from butt to tip. A pink rot, known as *Fusarium*

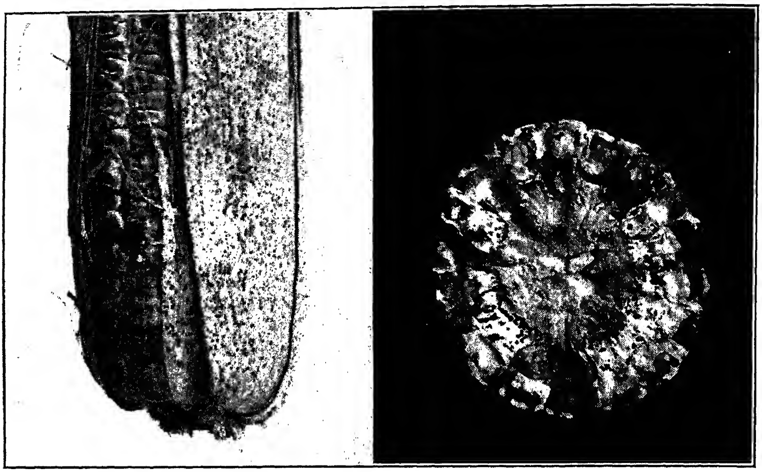


FIG. 79. An ear of corn and a cross section of an ear that are in a rotted condition because of a disease caused by the *Diplodia* fungus. (*Illinois Agricultural Experiment Station and Agricultural Extension Service.*)

moniliforme, may be found on a few kernels scattered over an ear, or a large portion of the ear may be infected. A reddish-colored rot which starts at the tip end of an ear and usually destroys only a part of the ear is the result of an infection with *Gibberella zeae.*

In addition there are still other diseases which attack the ears of corn.

The fungus organism *Ustilago zeae* produces the well-known smut boils or galls which occur on corn plants. In the early stages the diseased growth appears in the form of white, irregularly shaped swellings which vary in size from small pustules a fraction of an inch in diameter to large growths which may be several inches in thickness or diameter. The swellings, upon maturity, break open and release millions of smut spores which are blown about by the wind.

A disease which takes heavy toll of early maturing sweet corn, popcorn, and flint corn is a bacterial wilt known as *Stewart's disease.*

It occasionally attacks late corn. Corn plants may wilt and die at an early stage of growth or live long enough to form ears.

Diplodia and *Fusarium* fungi, as well as bacterial rots, cause damage to corn stalks. Infected stalks commonly break down, thus resulting in what is termed *down corn.*

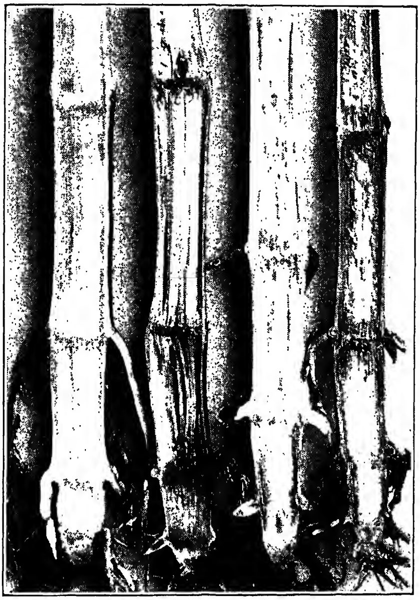


FIG. 80. The corn stalk at the left is in a healthy condition. The stalks to the right are rotted because they are infected with the *Diplodia* fungus. (*Illinois Agricultural Experiment Station and Agricultural Extension Service.*)

Because of the many diseases which attack corn, it is well for corn growers to investigate the possibilities of avoiding losses from such sources. Perhaps one of the best methods is to use disease-resistant seed. Much progress has been made in developing corn hybrids, which are disease-resistant in a marked degree. In addition to using seed which is genetically disease-resistant, it is important to care for seed corn in such a manner as to prevent infection. Quick drying and proper storing of seed should be emphasized in combating disease. Avoid using damaged ears or ears which have any abnormal conditions. Germination tests are often very useful in detecting diseased and weakened ears.

Botanical Classification and Characteristics of Corn. Corn belongs to the Graminae (Poaceae) or grass family of plants. According to Jenkins (176), it is a representative of the tribe Maydeae composed of eight genera (five oriental and three American) of which *Zea* is the most important of the American genera. The species, *Z. mays*, is the well-known Indian corn or maize. Sturtevant classified or divided *Z. mays* into a number of sub-species or groups as follows: *Z. indentata*, dent corn; *Z. saccharata*, sweet corn; *Z. indurata*, flint corn; *Z. everta*, popcorn; *Z. amylacea*, soft corn; *Z. tunicata*, pod corn. Instead of three words, such as *Z. mays indentata*, being used in the nomenclature of classification, the word *mays* is omitted in each case in order to preserve the binomial system of using two words in the scientific name of a plant. It is becoming common practice, however, to use *Z. mays* as the only species and to refer to various agricultural varieties by their common names.

Corn is a summer annual since it completes its growth in the summer after spring planting. It has a fibrous root system which often extends to a depth of 5 or 6 feet. The great mass of the root system is found in the top 4 or 5 inches of the soil. From nodes just above the surface of the soil, there arises whorls of aerial roots which are the so-called *brace* or *prop* roots.

The corn stem varies from 3 to 15 or more feet in height, depending upon the variety. The internodes are filled with pith, traversed by vascular bundles or fibers. Secondary stems sometimes arise from the lower nodes. These growths are often called *suckers* and correspond to the *stooling* or *tillering* which characterizes the growth of such common cereals as wheat and oats.

The leaves of the corn plant arise from the nodes in the form of leaf sheaths which closely envelop the stem for some distance above the nodes. At the top of the sheath is the ligule that surrounds the stem and from which the blade of the leaf extends away from the stem. The leaves occur alternately on the opposite side of the stem.

Corn is *monoecious* because the staminate and pistillate flowers, or inflorescences, occur upon the same plant. The *tassel* or *staminate* inflorescence occurs in panicle form at the top of the stalk, whereas the *ear* or *pistillate* inflorescence arises from the axil of a leaf lower on the stem. The ear is in the form of a compound spike, extending from a shank or branch. Modified leaves, arising from nodes along the shank, form the husk of the ear.

Origin and History. Various authors (176) indicate that corn is probably the oldest cultivated cereal and that its exact origin is a

mystery. When America was discovered corn was being grown by the Indians at that time. Ancient Aztec and Peruvian pottery pieces have been found to be decorated with corn motifs. Corn was found in the remains of the Basket Maker Indians of Utah, the Mound Builders of Ohio, and in the graves of Indians in many other parts of America.

Wild plants that resemble corn have been found only in America. Teosinte, a wild plant found in the foothills of Central America and southeastern Mexico, resembles corn somewhat and, in addition, hybridizes with corn. Although the evidence is far from being conclusive, there is some reason to believe that corn may have originated in the highlands of Peru, Bolivia, Ecuador, an area in southern Mexico, and in Central America.

Standard Corn Belt Varieties. It would be unnecessary and impossible to list and describe the 2000 or more corn varieties grown throughout corn-growing regions. The following are recognized as parent varieties from which many others have been developed, and which are leading varieties over broad areas.

Leading Corn Belt Varieties

Northern Corn Belt	Silver King, Golden Glow, Northwestern Dent
Central Corn Belt	Reid's Yellow Dent, Leaming, Boone County White
Southern Corn Belt	Reid's Yellow Dent, Boone County White, St. Charles White

The Reid's Yellow Dent is recognized as a leading variety for the rich soils of the Corn Belt. Many other strains have been developed from the Reid's by selection, such as the Iodent in Iowa and the Pickett in Michigan. Reid's Yellow Dent was developed by James L. Reid, in northern Illinois, from a hybrid of the Gordon Hopkins variety brought by his father from Brown County, Ohio, in 1846. This variety, a large, reddish corn, proved to be late in maturing and was crossed the next year by replanting with a smaller and earlier yellow dent corn. From this hybrid the modern Reid's was developed. In the Reid's and the Pickett, a northern selection, the reddish color of the original Hopkins is frequently noticeable at the sides of the kernels.

This variety is one of the outstanding leaders of corn-yield contests and corn shows. It is extremely uniform and cylindrical in shape, with slight taper, and deep, keystone-shaped, large-germed kernels. The butts and tips are well covered and the cob is small. The color

is a rich yellow. This variety requires 110 to 120 days to mature. The ears are 9 to 10 inches long and 7 to $7\frac{1}{2}$ inches in circumference.

A monument recently has been erected by national subscription to the late James L. Reid for his service to the nation in developing a variety which has added millions of dollars to the value of the corn crop.

Leaming Yellow Dent is the oldest and one of the most widely grown varieties of the Corn Belt. It was developed in 1856 by J. S. Leaming, in Champaign County, Ohio, from stock brought north by him when he moved from Hamilton County in southwestern Ohio. This original stock probably was brought from Virginia, when this district was settled as part of the Virginia Land Grant. Mr. Leaming selected his seed in the field from vigorous stalks of early maturity. This variety is marked by strongly tapering ears, large butts, usually smoothly indented kernels, and deep-yellow color. The Leaming of the southern Corn Belt is larger with a rougher indentation. Many varieties have been developed from it by selection. The ears average 9 to 10 inches in length and 7 to $7\frac{3}{4}$ inches in circumference, and require a growing season of 110 to 120 days for full maturity.

The Boone County White was developed in Boone County, northwestern Indiana, by James Riley, from a selection made in 1876, from the White Mastodon. The stalk is heavily leaved and vigorous. The ears range 9 to 11 inches in size and $7\frac{1}{2}$ to 8 inches in circumference. The ear is cylindrical in shape, with straight rows, and is uniform. This variety requires 120 to 125 days to ripen. The Johnson County White is very similar, and in many localities the name Johnson has been discarded in favor of Boone.

The Boone County White is the most widely grown white variety of the Corn Belt.

The St. Charles White is an old variety of St. Charles County, Missouri. It requires 125 to 130 days to ripen and makes a rank stalk growth. The ears are large, 10 to $11\frac{1}{2}$ inches, taper strongly, and have a blood-red, very distinctive cob.

The Silver King, a white dent, was developed at Fort Atkinson, Iowa, from seed brought from Indiana, in 1862, by H. J. Goddard. He practiced field-seed selection in the fall, selecting large ears with deep, wide kernels borne on small cobs. The ears require 100 to 110 days to mature, and range from 8 to 9 inches in length and $6\frac{3}{4}$ to $7\frac{1}{2}$ inches in circumference.

The Wisconsin 7 is a selection of this variety.

The Minnesota 13 was originated by the Minnesota Experiment Station in 1893. It is an early variety, maturing in 100 to 110 days.

The ears are 7 to 8 inches long, smoothly indented, with 12 to 16 rows of kernels.

The Golden Glow was developed at the Wisconsin Experiment Station from the Minnesota 13 and a local yellow dent variety. This

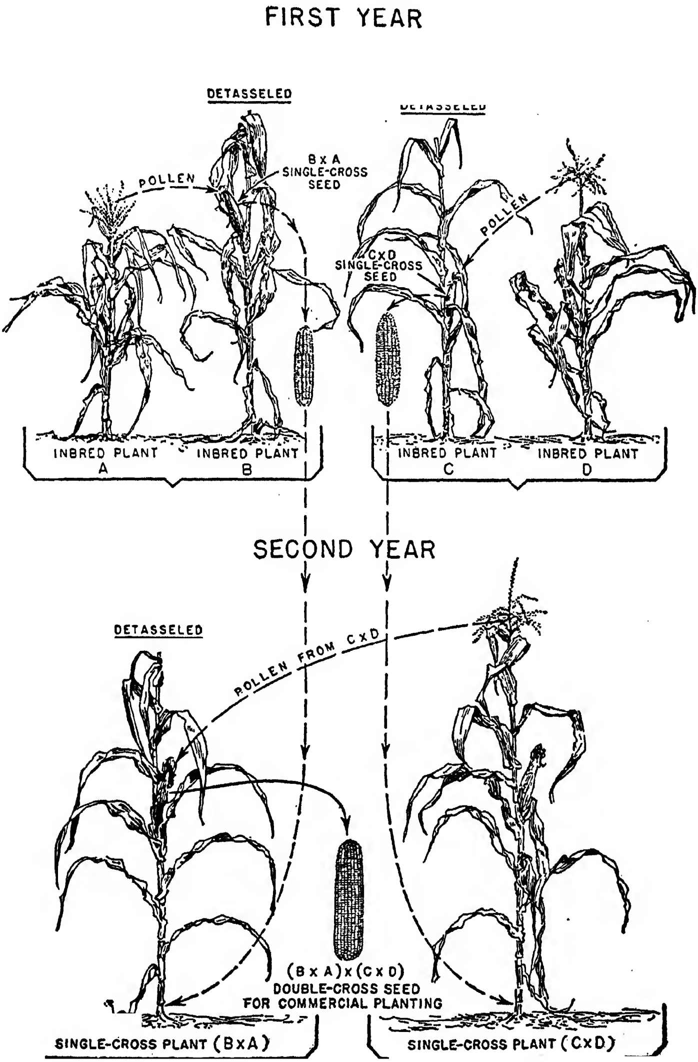


FIG. 81. This diagram illustrates the production of double-cross hybrid seed corn. (*Iowa State College Extension Service.*)

variety is a leading one in northern corn-growing regions. It is early, requiring only 90 to 110 days to ripen. The ears are a golden-yellow color, with smooth indentation, and range 6½ to 8 inches in length, carrying 14 to 16 rows of kernels.

The Northwestern Dent is a hardy, short-seasoned variety. It has red kernels, with a white or yellowish crown, and ears 6 to 9 inches in length.

The indentation is smooth, the crowns of the kernels often being flinty in nature.

FIG. 82. From such a field of corn, hybrid seed will be selected from the rows which have been detasseled. (*Iowa Agricultural Extension Service.*)

The flint varieties are earliest in maturing, and are grown farther north and at high altitudes. The stalks are shorter and the ears longer than those of the dent varieties. The kernels have flinty crowns. The smut nose, King Philip, Longfellow, Hall's Golden Nugget, and Mercer are leading varieties.

Hybrid Corn. Hybrid corn is now being grown on a large proportion of the Corn Belt acreage. Good hybrids have demonstrated their superiority over open-pollinated varieties.

The production of hybrid seed is rather simple in principle, but requires many techniques and procedures for successful accomplishment. The first procedure is to establish inbred lines through five or more generations of inbreeding. Each inbred line, representing rather stable breeding, must be evaluated then in terms of the qualities which are being sought in foundation stocks. Yield, growth characteristics, resistance to diseases and insects, and other heritable

qualities must be determined. The final procedure is to unite basic inbred lines in various combinations which will produce hybrid seed. A hybrid between two inbred lines is known as a single-cross hybrid. When two single-cross hybrids are used as parent stock, the result is known as a double cross. The cross between an inbred line and a single cross is known as a three-way cross. Most commercial hybrid corn seed is the double-cross product.

Composition of Corn. Both corn forage and corn grain are high in carbohydrates and low in protein. The composition of corn is presented in Table 16. Comparisons may be made by referring to Tables 49 and 50 of the Appendix.

TABLE 16 *

COMPOSITION OF CORN

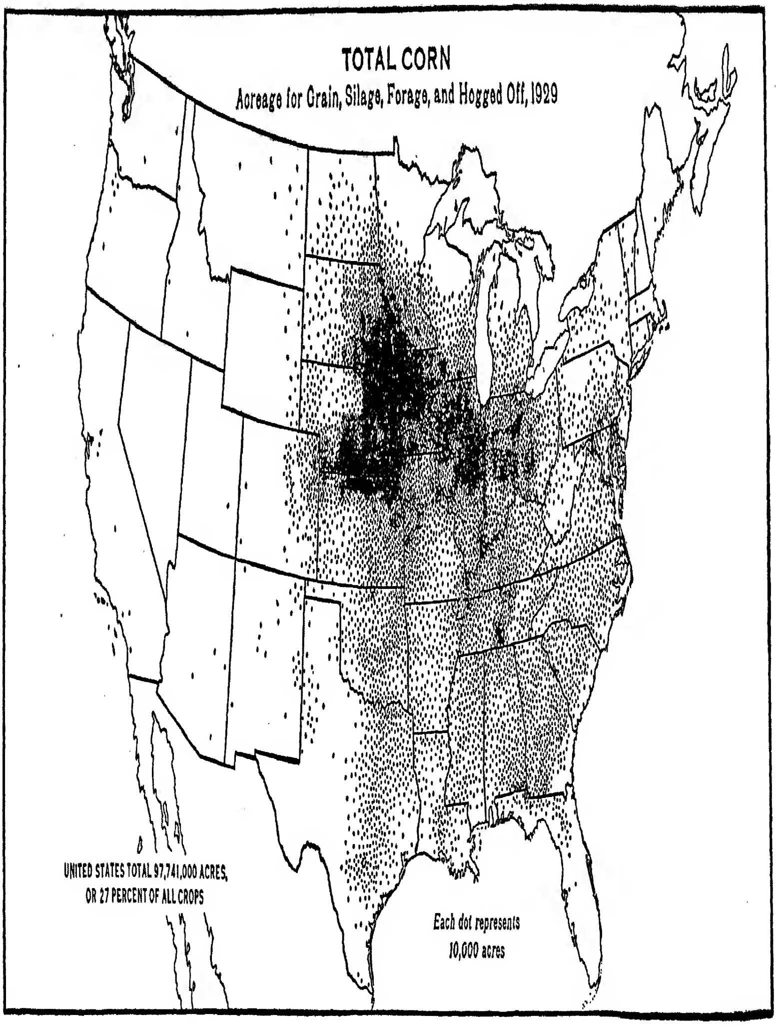
Foodstuff	Moisture	Ash	Crude Protein	Fat	Crude Fiber	Nitrogen-Free Extract †
	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)
Corn, shelled	12.9	1.3	9.3	4.3	1.9	70.3
Corn fodder	11.8	5.8	7.4	2.4	23.0	49.6
Corn fodder (green):						
Dent immature	79.0	1.2	1.7	0.5	5.6	12.0
Dent mature	73.4	1.5	2.0	0.9	6.7	15.5
Corn stover	10.7	6.1	5.7	1.5	30.3	45.7
Corn silage	73.8	1.7	2.1	0.8	6.3	15.3

* United States Department of Agriculture, Yearbook of Agriculture, 1939.
† Carbohydrates except fiber.

In connection with vitamin content (179), the yellow corn grain contains 3180 international units of vitamin A per pound, 270 international units of vitamin B per pound, and no vitamin D; is considered a good source of vitamin E; and contains 450 micrograms of vitamin G (riboflavin) per pound. White corn has the same content except that it lacks vitamin A.

Areas of Corn Production. The areas of corn production in the United States are indicated in Fig. 83. The dark sections of the map reveal the general outline of the Corn Belt.

Corn-Production Statistics. Information pertaining to corn production in the United States is presented in Table 17. Statistics re-


TOTAL CORN
Acreage for Grain, Silage, Forage, and Hogged Off, 1929
UNITED STATES TOTAL 97,741,000 ACRES,
OR 27 PERCENT OF ALL CROPS
Each dot represents
10,000 acres

(U.S.D.A.)

Fig. 83.

lating to the world production of corn and to the production in selected countries is found in Table 18. For further information refer to the current annual issue of Agricultural Statistics, published by the United States Department of Agriculture.

TABLE 17 *

CORN: ACREAGE, PRODUCTION, VALUE, AND FOREIGN TRADE, UNITED STATES, 1934–1940

Year	Acreage Harvested	Average Yield per Acre	Production: In Grain Equivalent on Entire Acreage	Production: Harvested as Grain	Season Average Price per Bushel Received by Farmers	Farm Value
	(1000 acres)	(Bushels)	(1000 bushels)	(1000 bushels)	(Cents)	($1000)
1934	92,354	15.8	1,461,123	1,146,684	81.5	1,190,612
1935	95,804	24.0	2,303,747	2,015,007	65.5	1,509,147
1936	93,020	16.2	1,507,089	1,253,766	104.5	1,573,865
1937	93,741	28.3	2,651,284	2,350,299	51.8	1,372,468
1938	92,222	27.8	2,562,197	2,303,265	48.7	1,247,010
1939	88,430	29.4	2,602,133	2,342,710	56.7	1,476,300
1940	86,449	28.3	2,449,200	2,175,747	62.4	1,528,440

* United States Department of Agriculture, Agricultural Statistics, 1941.

TABLE 18 *

CORN: PRODUCTION, WORLD AND SELECTED COUNTRIES, 1934–1938

Year of Harvest	Estimated World Total	Estimated European Total	Selected Countries: United States	Danube Basin Countries	Argentina	Brazil	Soviet Union	Italy	Union of South Africa
	(Million bushels)	(Million bushels)	(Million bushels)	(Million bushels)	(Million bushels)	(Million bushels)	(Million bushels)	(Million bushels)	(Million bushels)
1934	3925	883	1461	507	452	234	151	126	66
1935	4604	729	2304	427	396	226	110	98	53
1936	4064	922	1507	561	360	261		120	100
1937	4928	919	2651	540	174			134	69
1938	4869	863	2542	510	213			116	106

* United States Department of Agriculture, Agricultural Statistics, 1939.

The leading states in corn production, in terms of their average, harvested acreages for the period of 1927 to 1936, are: Iowa, 10,-

968,000; Nebraska, 9,104,000; Illinois, 8,926,000; Kansas, 5,849,000; Missouri, 5,680,000.

Uses of Corn. About 90 per cent of the corn crop is used for animal feeding. In the form of silage it provides an excellent feed, in the rations of dairy cattle in particular. It may also be fed advantageously to beef cattle and sheep. Corn is often cut while still green, and fed as green fodder when pastures may be short. Corn fodder (ears and stalk) and corn stover (the stalks with the ears) are commonly fed to cattle and sheep. Corn grain is one of the best concentrate feeds for livestock of all classes when it is used with certain proteins to balance its deficiencies.

About 10 per cent of the corn crop is being used in industry. For example, the stalks are used in the manufacture of wallboard. In the corn-refining industry, many useful products are derived from corn. Corn oil and corn-germ meal are obtained from the corn germs or embryos. Corn-gluten feed is a by-product of the refining process. Corn starch is used as edible starch, in textiles, paper, for laundry work, and for similar purposes. Dextrins that are derived from the starches are used in textiles, paper, and adhesives. Syrups from the starches are used in confections, jams, jellies, preserves, for table use, and are valuable in many other ways. Sugar that is made from corn starches is used in ice cream, beverages, brewing, and pharmaceuticals.

Corn Grades. Table 19 is from the "Handbook of Official Grain Standards" of the United States (168). In addition to the information presented in Table 19, the Handbook describes numerous special grades and also presents definitions that are important in the marketing of corn.

Corn Research. Much attention is being given to research, relating to corn. For detailed information pertaining to the improvement of corn, it is suggested that reference be made to the section in the 1937 Yearbook of Agriculture, entitled "Corn Improvement," by Merle T. Jenkins (177).

It is further suggested that use be made of Senate Document 65 of the first session of the 76th Congress, entitled Regional Research Laboratories (130). In this volume there is to be found a comprehensive survey of present and proposed research relating to corn. The following, selected from this publication, indicates to some extent the scope of present research.

1. Genetic studies on corn are directed toward the isolation of inbred lines and resynthesis of hybrids characterized by disease and insect resistance, ad-

TABLE 19 *

GRADE REQUIREMENTS FOR YELLOW CORN, WHITE CORN, AND MIXED CORN

Grade No.	Minimum Test Weight per Bushel	Maximum Limits			
		Moisture	Cracked corn and foreign material	Damaged kernels	
				Total	Heat-damaged
	(Pounds)	(Per cent)	(Per cent)	(Per cent)	(Per cent)
1	54	14.0	2	3	0.1
2	53	15.5	3	5	0.2
3	51	17.5	4	7	0.5
4	48	20.0	5	10	1.0
5	44	23.0	7	15	3.0
Sample grade	Sample grade shall include corn of the class Yellow Corn, or White Corn, or Mixed Corn, which does not come within the requirements of any of the grades from 1 to 5, inclusive; or which contains stones and/or cinders; or which is musty, or sour, or heating, or hot; or which has any commercially objectionable foreign odor; or which is otherwise of distinctly low quality.				

* United States Department of Agriculture, Handbook of Official Grain Standards.

justment to environmental conditions, stiffness of stalk, large root systems and other factors contributing to yield and quality of crop. Application of this type of research to synthesis of hybrids with qualities for particular processing purposes has been limited mostly to sweet corn and popcorn, to white corn for dry milling, or to abnormal protein and fat levels in field corn.

2. Agronomic studies on corn are in progress at most of the agricultural experiment stations. These studies have for their purpose the determination of the effect of type of soil, climatic factors, cultural methods, and other variables upon insect infestation, yield, and quality of crop.

3. Scattered research is being performed on the variation in the constituent vitamins, pigments, carbohydrates, proteins, fatty oils, odoriferous principles, and enzymes of corn as a result of genetic or agronomic practices.

4. Research on harvesting, drying, and storing of corn is prosecuted to preserve the quality of the product and to decrease losses from storage diseases, insects, and other pests.

5. Extensive feeding studies of the entire corn plant and the whole grain are being conducted, since corn is the basic constituent of most concentrated feeding rations in the Central States. Use of the essential amino acids and fractions of the kernel produced as byproducts of the various processing industries is also being studied from the nutritional standpoint.

Moreover, research is being carried on with corn concerning: Dry- and wet-milling processes; starches and sugars; general fermentation; yeast fermentation; mold fermentation; bacterial fermentation; saccharification; motor fuels; by-products and wastes. The 1937 Yearbook of Agriculture also gives a long list of suggested research projects.

It is evident that the future promises much in the way of discovery pertaining to corn production and utilization.

CHAPTER XVIII

WHEAT AND RYE

WHEAT

According to the official grain standards of the United States, wheat is divided into five classes, as follows: Hard red spring wheat; Durum wheat; Hard red winter wheat; Soft red winter wheat; White wheats.

Since there is considerable variation in the production factors and practices between these classes of wheat, each will receive separate treatment in the following discussion.

Spring Wheat

As graphically shown in Fig. 90, the center of spring-wheat production is in North Dakota, South Dakota, eastern Montana, and western Minnesota. Canada is also a large producer of spring wheat, devoting 23,000,000 to 25,000,000 acres annually to its production.

Climatic Factors in Spring-Wheat Production. In regions where it can be grown successfully, winter wheat is more profitable than spring wheat. Spring wheat, on the other hand, is grown in areas north of the winter wheat belt, wherein winter wheat cannot be grown successfully.

Soils in Spring-Wheat Production. The Barnes loam areas of the chernozem soils comprise the upland soils of North Dakota, South Dakota, and western Minnesota on which spring wheat is grown (178). The surface layer consists of 10 to 15 inches of black loam, underlain by a layer of brown loam 4 to 12 inches thick. Below these layers is found a light grayish-brown or almost white material of a calcareous nature.

The Red River Valley soils in eastern North Dakota and western Minnesota are used to a large extent in spring wheat production. The Fargo soils in this area have heavy black surface soils, ranging in thickness from 10 to 12 inches, underlain by gray calcareous clays;

the Bearden soils have silt loam or very fine sandy loam surface soils, underlain at a depth of 12 to 24 inches by gray silt loam. The Fargo and Bearden soils have developed on the soil material that fills old lake beds.

Seed-Bed Preparation for Spring Wheat. Information from the South Dakota Station (58), as presented in Table 20, provides an excellent summary of seed-bed-preparation practices.

TABLE 20

SEVEN YEARS' AVERAGE, 1919 TO 1925, OF WHEAT FROM DIFFERENT METHODS OF SOIL PREPARATION AT EUREKA, SOUTH DAKOTA

Wheat, summer fallow	18.5 bushels
Continuous wheat, spring plowed	17.5 bushels
Continuous wheat, fall plowed	14.7 bushels
Continuous wheat, fall plowed every third year and disced other two years	13.1 bushels
Wheat, checked corn*	19.6 bushels
Wheat, drilled corn*	21.8 bushels
Wheat, sweet clover, checked corn*	19.2 bushels
Wheat, listed corn*	20.7 bushels

* In the rotations where wheat follows corn, the land was double disced and harrowed before wheat was seeded.

As may be noted in the South Dakota results (Table 20), spring wheat yields are increased when grown in rotation. Tests on the Great Plains (59) have shown that the largest returns of wheat per acre were produced on summer fallow. The cost of summer tillage and the trouble with soil blowing during the winter, however, resulted in its being more profitable to produce spring wheat on disced corn or potato ground. The yields of spring wheat on the Agronomy Farm at Laramie, Wyoming, have been greatly increased by the use of a rotation of alfalfa, potatoes, and grain.

Under conditions where spring wheat is grown continuously, or under other conditions which make it necessary to plow land for wheat, it has been found by experiments conducted at fourteen stations by the United States Department of Agriculture that results are the same with either fall or spring plowing so far as yields are concerned. Other factors, such as labor distribution and soil blowing, rather than yields must be considered in determining the choice between fall or spring plowing. In any event, the plowing should be done at a time which will allow for preparing a firm seed bed for early planting.

Plowing is unnecessary when wheat is to follow a cultivated crop. A suitable seed bed under such circumstances may be prepared by using a disc or duckfoot cultivator, followed by harrowing.

In dry-farming areas the lister may be used, and by running the furrows at right angles to the prevailing winds less difficulty from soil blowing results.

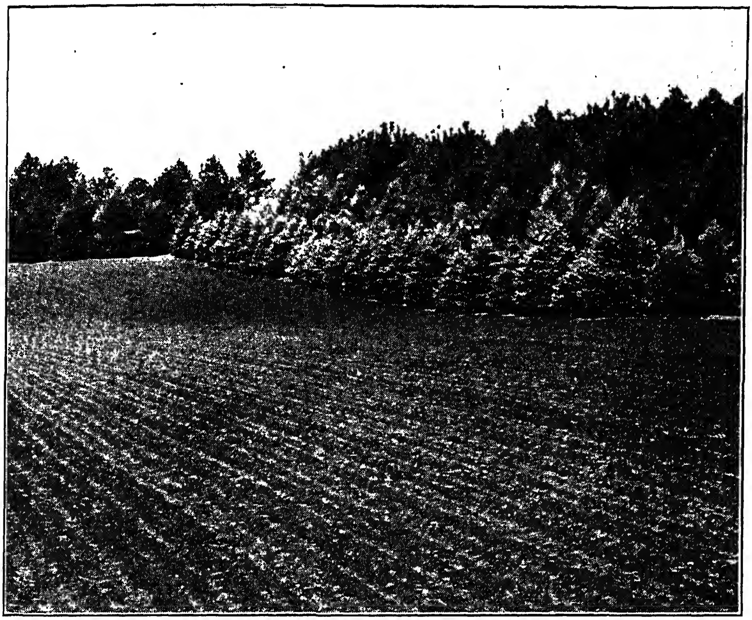


FIG. 84. Windbreaks aid in the retention of soil moisture and reduce losses of soil from wind erosion and from winter killing of wheat or other fall-planted crops. (*U.S.D.A.*)

Time of Seeding Spring Wheat. Experiments in South Dakota (58) indicate that the best yields of wheat are obtained from early seedings, ranging from March 15 to April 1. Other things being equal, early planted wheat matures earlier, and this is a very important factor in escaping rust infection which usually reduces the yields of late-maturing wheat.

Rate of Seeding Spring Wheat. It was found at the South Dakota Station (58), at Highmore, that 6 pecks per acre was the most profitable rate of seeding.

Spring Wheat under Irrigation. According to the recommendation of the Wyoming Station (59), spring wheat on irrigated land should be grown in rotation because of the need to stir the soil and break up the puddled clods which form under irrigation. Spring wheat following such cultivated crops as corn, potatoes, sugar beets, or beans, to be in turn followed by alfalfa or clover, seems to be the best rotation.

If the wheat is grown in a rotation following a cultivated crop, the seed bed is prepared by discing or by using a duckfoot cultivator. Should the seed bed need additional smoothing and compacting, this may be followed by harrowing and packing.

Fall plowing for spring wheat is advisable on the irrigated lands of Wyoming where soil blowing is not a factor. Such procedure usually results in a better physical condition of the soil. According to the Wyoming Station (59), all wheat under irrigation should be drilled to a depth of 1½ to 2 inches. To aid in directing the water on nearly level land, the drilling should be done in the same direction as the slope. From 90 to 110 pounds of seed should be used per acre, with somewhat lighter rates being used if alfalfa or clover is to be seeded in the wheat. Early seedings in the latter part of March or the first of April are most profitable.

Wyoming investigations (59) indicate that the proper use of irrigation water is an important factor in wheat production. It is suggested that early irrigations of spring wheat should be avoided especially before the wheat comes up. In sections where the early spring is usually dry, a late-fall irrigation of the land will ordinarily be sufficient for the first needs of the crop. Applications of water at jointing and flowering time appear to be most desirable. Water should not be applied during the time the wheat is maturing.

Durum Wheat

Durum wheat is produced almost entirely in North and South Dakota and in Minnesota. The grain is used largely in the manufacture of spaghetti, macaroni, and other similar products. It is a spring-sown wheat, and the factors relating to its production are similar to spring wheat already considered.

For the period 1927 to 1936 the states of Minnesota, North Dakota, and South Dakota together had an average production of about 40,000,000 bushels.

Hard Red Winter Wheat

Hard red winter wheat is produced for the most part in the state of Kansas and in the adjacent portions of Oklahoma, Colorado, and Nebraska, with some production extending into Illinois.

During the period 1925 to 1938, the year of highest production was 1931, when 514,000,000 bushels were produced. The lowest production of nearly 177,000,000 bushels occurred in the year 1933. In the year 1937, the yield was approximately 373,000,000 bushels, and in 1938, the amount was approximately 387,000,000 bushels.

Soils in Hard Red Winter Wheat Production. The Keith area (178) of the chestnut soils forms a large area in western Kansas, southwestern Nebraska, and northeastern Colorado. The Keith silt loam has a surface soil which is a dark grayish-brown, mellow silt loam. The upper subsoil is dark grayish-brown and slightly heavier than the surface soil. Winter wheat is grown exclusively in a large part of the area. The Greensburg-Pullman-Richfield areas (178) of the reddish chestnut soils, found in southern Kansas and in the Texas and Oklahoma Panhandles, are largely devoted to the production of hard winter wheat. Wheat occupies as much as 80 to 90 per cent of the cropland. These soils have brown to very dark-brown surface soils over dark-brown to reddish-brown subsoils.

Hard Red Winter Wheat in Crop Rotations. It is pointed out by Leighty (178) that definite crop rotations are not a part of farming practice in the important wheat-producing areas. Uncertain climatic conditions which interfere with regularity of crop sequences, lack of crops which are well adapted to rotations, and the fact that other crops are not generally as profitable as wheat in these regions are factors which tend to prevent the use of rotations.

Investigations at the Kansas Station (138) indicate that it is important to grow wheat in rotation in the Manhattan area. A ten-year average resulted in an average production of 26.8 bushels per acre when wheat was grown in rotation with corn and oats, as compared to an average of 15 bushels when grown without rotation.

In northeastern Kansas, a popular rotation includes clover, corn, corn, oats, and wheat. On good wheat land, two crops of wheat may be grown or one of the corn crops may be omitted. Kafir or other sorghums may be substituted for corn on poor and droughty lands, and soybeans or cowpeas for hay may be substituted for oats.

In central Kansas, thé rotation often includes alfalfa. The alfalfa should be followed by an early maturing sorghum. The sorghum may be followed by corn on the better land, and the corn by oats and then wheat. The corn may be omitted, which means that the sorghum will be followed by oats or barley and then wheat. The crops occur in these rotations in the order mentioned because of the danger of wheat's lodging if it comes immediately after a legume.

According to extensive experiments (138) at the Fort Hays, Colby, and Garden City branch stations in western Kansas, there is no marked gain in the yield of wheat as a result of growing in rotation with other crops except where fallow is included.

Fertilization of Hard Red Winter Wheat. Under soil and climatic conditions similar to those in western Kansas, it is seldom profitable to use commercial fertilizers or barnyard manure on winter wheat.

In central Kansas (138), applications of 5 to 6 tons per acre of manure once in three or four years and, in eastern Kansas, applications as high as 8 to 10 tons per acre may be profitable. At the Kansas Station at Manhattan, applications of manure on reasonably fertile soils have shown an average gain of 4 to 6 bushels per acre as a result.

In eastern Kansas, superphosphate or mixed fertilizers, such as 2–16–0, may be applied at the rate of 125 to 150 pounds per acre with a combination grain and fertilizer drill. The fertilizer may be scattered broadcast and harrowed in, but results are not as satisfactory as when drilled at the time of seeding.

It may be expected that this information, which is applicable to Kansas, will apply rather generally in the regions where hard red winter wheat is produced.

Seed-Bed Preparation. According to a report of the Kansas Station (138), the best plan to follow in eastern Kansas, if the previous crop is oats or wheat, is to plow in July or early August to a depth of 6 to 7 inches, turning under all stubble and weeds. As soon as weeds and volunteer grain become well started, double disc, then continue cultivation to control weeds and provide good soil conditions. Disc the ground immediately after harvest, if it cannot be plowed, and plow as soon as conditions permit.

In central and western Kansas, the most important consideration is that of adopting methods which will store and conserve moisture. The results to be obtained from early or late plowing depend upon seasonal conditions. In wet seasons it is essential to plow early in

these regions. In dry seasons, there seems to be little choice between early and late plowing so far as influence on yields is concerned.

Early listing in western Kansas gives results second only to fallow. Summer fallowing results in the highest average yields, but the cost and the danger of soil blowing may result in the procedure's being rather unprofitable.

A process called *discing and stubbling in wheat* is used occasionally in western Kansas. Wheat is sometimes seeded in grain stubble without any preparations or with early discing. Under certain conditions the practice is profitable. There is economy in preparation, and damage from soil blowing is prevented. It appears that the practice should not be followed year after year but should be rotated with other methods. Discing may be done with the one-way disc plow or the wheatland plow, as it is frequently called. The implement is a heavy disc harrow with all the discs set one way.

When straw is left on the ground, as in combining, trouble often results from plowing under so much straw. Instead of burning the straw and stubble or plowing it under, it is recommended that the lister, disc harrow, or one-way disc harrow be used. These machine operations will leave a considerable portion of the straw at or near the surface.

Time of Seeding Hard Red Winter Wheat. Winter wheat should be sown early enough to allow for sufficient growth in the fall and to prevent winter killing. If there is danger of hessian-fly infestation, however, it is essential to delay seeding until a fly-free date. In states where winter wheat is grown, information is available to growers, pertaining to safe dates for planting so far as the hessian fly is concerned. Under favorable conditions winter wheat may usually be planted about the middle of September.

Seeding Hard Red Winter Wheat. In eastern Kansas (138), 1 to 1½ inches of soil over the seed is sufficient. Under western Kansas conditions, it is essential to plant deep enough to insure moist conditions around the seed. Drilling to a depth of 2 or 3 inches may be necessary.

Seeding is usually done with a disc drill. In rather dry areas where winter wheat is grown, the lister drill may be used to advantage as it places the seed in furrows 12 to 14 inches apart and at a greater depth than the usual disc drill.

According to Kansas recommendations (138), 4 to 6 pecks of seed produce the best results for seedings made in the latter half of Sep-

tember in the eastern portion of the state. After October 1, it has been found better to use about 8 pecks of seed. In central Kansas, 4 pecks for early seeding on well-prepared ground seem sufficient, while rates of 2 to 3 pecks have been sufficient in the extreme western portions of the state. Somewhat larger amounts of seed, however, may often be used to advantage as insurance against unfavorable conditions.

Pasturing Hard Red Winter Wheat. According to the Kansas Station (157), 65 per cent of the winter wheat acreage in that state is pastured to some extent. It has been found that wheat can be profitably pastured from the standpoint of livestock gains. Usually the yield of wheat is not reduced and may be somewhat increased when a properly managed, moderate grazing program is practiced.

At the Kansas Station, Hays branch (157), the effect of moderate fall pasturing for a period of sixty days on the yield of wheat grown on fallowed land, during the years 1926 to 1930, resulted in an average gain of 3 bushels per acre for the five-year period. Longer periods of pasturing reduced the gains, and pasturing late in the spring after plants had made an upright growth also resulted in reductions in yields.

On cropped land it was found that moderate pasturing resulted in gains if the wheat had made a vigorous growth.

Harvesting Hard Red Winter Wheat. Hard winter wheat may be harvested by cutting with a binder with subsequent shocking and threshing, by harvesting with a header, or by combining. There has been a great increase in the use of the combine during recent years. When precautions are taken to avoid trouble from excessive moisture in the harvested grain, the combine method seems to be very practical in that the costs of harvesting and threshing are usually reduced in comparison with other methods.

Soft Red Winter Wheat

The Soft Red Winter Wheat Belt extends eastward from the Hard Winter Wheat Belt through the Corn Belt into New York, Pennsylvania, Delaware, and Maryland, and to a small extent as far south as Tennessee and North Carolina.

During the period 1925 to 1938, the smallest production, about 127,000,000 bushels, occurred in the year 1928. The largest produc-

tion, 262,000,000 bushels, occurred in 1931, while the production in 1937 was nearly 258,000,000 bushels, and in 1938 about 237,000,000 bushels.

Soft winter wheat is used especially for making flour used for cakes, biscuits, and pastry purposes.

Soft Red Winter Wheat in Crop Rotations. Soft red winter wheat is grown on many Corn Belt farms not only because it is an impor-

FIG. 85. Winter wheats are tested at the Michigan Agricultural Experiment Station for winter hardiness. An unadapted variety (foreground) showed only a 10 per cent survival after a very mild winter. (*Michigan Agricultural Extension Service.*)

tant cash crop but because it lends itself to the planting of clover and grass which are essential crops in a rotation.

A corn, wheat, and clover rotation is very commonly used. The wheat is planted in the standing corn with a one-horse drill or is planted after the corn has been cut and shocked. Other rotations are as follows: corn, corn, wheat, clover; corn, corn, oats, wheat, clover; corn, oats, wheat, clover. The growing popularity of soybeans has resulted in including this crop in rotations, such as corn, soybeans, wheat, clover. In many rotations soybeans have taken the place of oats when it is possible to harvest the soybeans in time for the seeding of wheat.

Varieties of Soft Red Winter Wheat. The varieties of Soft red winter wheat to be used are listed in Table 51 in the Appendix. It is essential to use varieties that have desirable milling and baking qualities, coupled with winter hardiness, disease resistance, and high yields. Information as to varieties is also to be found in the 1936 "Yearbook of Agriculture."

Seed-Bed Preparation for Soft Red Winter Wheat. Wheat may be seeded in standing corn without soil preparation other than clean cultivation of the corn. When wheat is to be seeded on land where corn has been removed, the seed bed is commonly double disced and harrowed.

When wheat follows oats or other summer-harvested crops, with the exception of soybeans, the ground should be plowed early, followed by immediate discing and then sufficient harrowing to destroy weeds and volunteer crop growth. It is essential to prepare a firm seed bed with enough loose surface soil to cover the seed.

On land from which soybeans have been removed, the soil is often in such a loose condition that no preparation is required for the seeding of the wheat in the soybean stubble. A very light discing sometimes may be necessary.

Time, Method, and Rate of Seeding Soft Red Winter Wheat. In most of the Corn Belt area where Soft red winter wheat is produced, there is usually a danger of infestation with the hessian fly. The time of seeding varies with the fly-free dates. In northern Indiana, for example, wheat usually may be seeded as early as the third week in September, while in the southern portion of the state, to escape difficulty, the date of seeding may need to be delayed to early October. Information about fly-free dates is available in any state or locality wherein the growing of winter wheat is important.

The usual procedure is to use a drill in seeding to obtain better results on depth of covering, germination, and stand. In order to prevent soil erosion, the direction of drilling should be across the slope or should follow the contour of the land.

Seven to eight pecks of seed are usually sufficient when good seed is to be used on well-prepared, properly fertilized soil, seeded at a favorable time. Late seeding or other unfavorable conditions may be remedied somewhat by increasing the rate of seeding.

Fertilization and Manuring of Soft Red Winter Wheat. According to results from the Indiana Station in work done at Lafayette (186),

300 pounds of 2–12–6 fertilizer per acre increased the average annual yield of wheat 9.1 bushels per acre in a corn, wheat, clover rotation during a twenty-year period. As a residual effect of the fertilizer, the clover-hay yield was increased an average of 375 pounds per acre, and the corn yield about 2 bushels per acre.

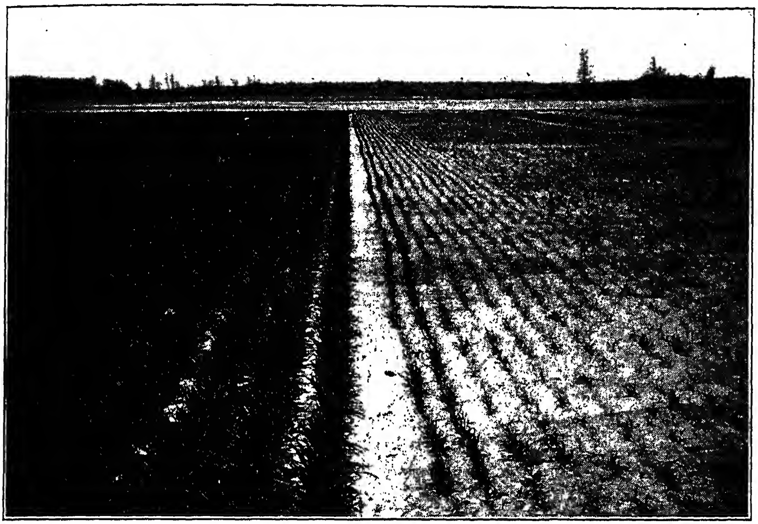


Fig. 86. How planting late affects the stand and vigor of winter wheat is illustrated above. The vigorous rows were planted September 22, while the less vigorous rows were planted October 12. (*Michigan Agricultural Extension Service.*)

General recommendations seem to indicate that from 200 to 400 pounds per acre of a 2–12–6 fertilizer should be used in wheat production.

Judging from Ohio Station investigations (56), the best method of fertilizing a corn, oats, wheat, clover rotation is to put a moderate application in the hill or row for corn, combined with a generous application on wheat. The crops in these investigations received the equivalent of 500 pounds of 4–16–4 per rotation. At the Indiana Station (186), it was found advisable in a corn, wheat, clover rotation to give wheat a light top dressing of manure (2 tons of a 6-ton allowance) in the winter, and to plow under the balance for corn. On sandy soils it was found best to divide the amounts equally between corn and wheat. The manure helped the wheat and, in addition, resulted in improved stands of clover.

At the Ohio Station at Wooster (56), investigations indicated no great difference from manure applied to the different crops in the rotation. It was evident, however, that placing a part of or all the manure on the wheat or new clover seeding improved the hay crop, and was preferable to putting all the manure on corn.

Under certain conditions the top dressing of wheat in the spring with a nitrogen fertilizer is profitable. Indiana investigations (186) indicate that a top dressing of 100 pounds per acre of nitrate of soda,

FIG. 87. Fertilized and unfertilized strips of wheat which illustrate how much more vigorously the wheat grows when it is well fertilized. (*Indiana Agricultural Experiment Station.*)

or kiln-dried sulphate of ammonia, or granular cyanamide, when there is evidence of insufficient nitrates in the soil, has increased yields from 5 to 7 or more bushels per acre, as an average of many experiments. Results in Indiana indicate that cyanamide should be applied in March, about the time growth begins. Sulphate of ammonia should be applied early in April, and nitrate of soda a little later when the wheat is 4 to 6 inches high.

Investigations conducted in Ohio (56) point out that top dressings with nitrogen are not likely to be profitable when either dry conditions or long periods of frozen ground have prevented the loss of nitrates through leaching. A pale-green or yellowish appearance of the wheat indicates a lack of nitrates, and the condition may be expected if there is much rain during the winter and spring.

Harvesting Soft Red Winter Wheat. Probably a major portion of Soft red winter wheat is harvested by the binder-thresher method, but the use of the combined harvester-thresher, or combine, is be-

coming widespread. An extensive study, in Indiana (186), of harvesting costs in the year 1936 showed the average cost of harvesting wheat with a small combine (6-foot cutter bar and under) was about one-half of the cost with the binder-thresher method.

White Wheat

Varieties of common white wheats such as Baart, Pacific bluestem, Goldcoin, White Federation, Onas, Bunyip, and Federation, and club wheats such as Poso, Big Club, Albit, and Jenkin are grown in the far Western States. A small amount of white wheat is grown in New York. These common white wheats include both winter and spring varieties.

Most of the white wheat is used in the making of pastry flour and for breakfast foods. Some use of white wheat is made in blending with hard wheats in producing flour for bread making.

GENERAL INFORMATION

Wheat Diseases. A number of diseases affect wheat rather seriously. A brief description of some of the wheat diseases is presented here.

Bunt or Stinking Smut. The forms of bunt or stinking smut are caused by two species of fungi, *Tilletia levis* and *T. tritici.* Spores from the soil under certain favorable conditions, but more commonly, spores carried on the seed, infect wheat in the seedling stage. The fungus develops with the growing wheat plants, enters the ovaries in the wheat spikelets, and matures as a spore ball in place of the grain kernel. In threshing, the spore bodies are broken open and the spores become disseminated over the grain, thus paving the way for a further spread of the disease unless the spores are destroyed.

The smut has a disagreeable odor and its presence in threshed wheat kernels reduces the sale value and the milling qualities of the wheat.

The treating of the seed with ethyl mercury phosphate dust or copper carbonate dust will destroy the spores.

Loose Smut. When wheat kernels that are infected with *Ustilago tritici* or loose smut are planted, the resulting plants develop spikes filled with the spore masses of the fungus. The spore bodies mature and break open about the time normal wheat spikes are in their periods of pollination. The spores from the diseased spikes infect the

flowers of healthy spikelets. As the wheat kernels develop, the infection is enclosed within the seed.

Since the disease material is found within the seed, it is necessary to use the hot-water method of seed treatment.

Black Stem Rust. Puccinia graminis tritici appears to be the causal organism of the well-known black stem rust of wheat. The

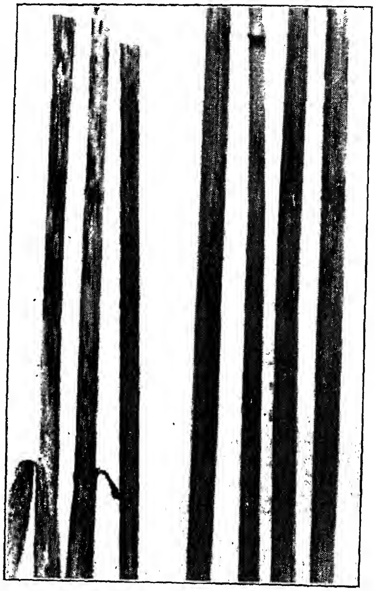


FIG. 88. Wheat stems which are infected with black stem rust. (*Ohio Agricultural Extension Service.*)

same disease affects many other grains and numerous wild and cultivated grasses. It seems particularly destructive in the spring-wheat areas.

In the northern areas, the disease overwinters in the form of black spores which develop in the late summer or early fall. In the spring, infective material from the black spores establishes a phase of the disease upon the leaves of the common barberry. Spores from the barberry form of the disease are carried by the wind to growing wheat plants where generations of the disease in its "red rust" or summer stage attack the stems and leaf sheaths of the wheat plants. As previously mentioned, the black spores develop late in the summer. In southern regions the red spores of the summer stage live over winter and infect wheat plants.

The eradication of common barberry plants in wheat-growing regions provides some means of control, as it prevents an early season start of the disease in the colder regions where the summer spores do not live through the winter. The use of early maturing varieties of wheat and of rust-resistant varieties and strains has served to curb the losses from this disease.

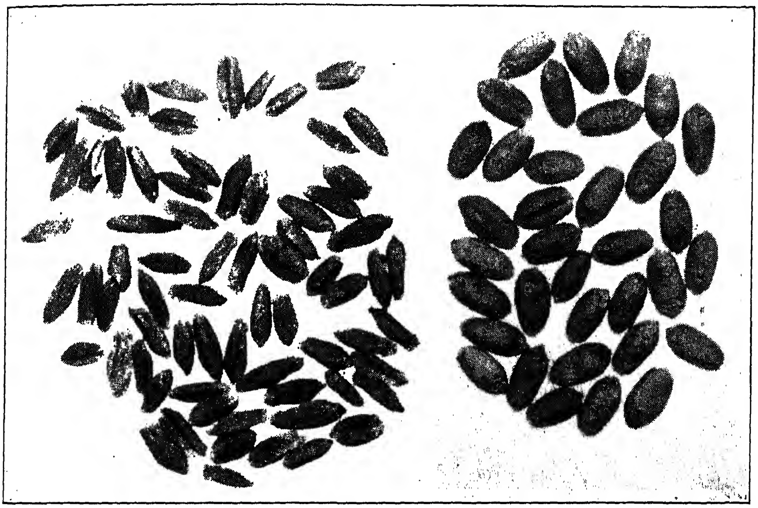


FIG. 89. The shrunken kernels from rust-infected wheat may be compared with the plump kernels of healthy wheat. (*Ohio Agricultural Extension Service.*)

Other Wheat Diseases. In addition to the above, wheat losses are caused by such diseases as fusarium blight or scab, forms of mildew, and leaf rust.

Wheat Insects. There are numerous insects which attack wheat and in some instances cause serious losses. Detailed information concerning these insects may be found in reference 100. A short description of some of the insects follows.

Green Bug. The green bug or grain aphid sometimes causes serious damage in the southwestern wheat-growing states. In southern areas, the insect overwinters in both the adult and nymphal stage. In northern regions, eggs live through the winter, hatching in late winter or early spring. Damage occurs when weather conditions favor the development of large numbers of insects. The insects suck the sap from the plants, and heavy infestations may kill all the plants in a field.

Very little control by man can be applied. The destruction in the spring of volunteer oats may be of some benefit.

Chinch Bug. This insect was discussed in connection with insects that attack corn. There seems to be no particularly effective methods of controlling chinch bugs in wheat.

Hessian Fly. The hessian fly lays eggs in the fall on fall-sown wheat. The eggs hatch and the larvae feed upon the sap of the plant. When mature the maggots become encased in brown puparia. These are often referred to as flaxseeds. In this condition the insect passes the winter. In the spring, the flies emerge and lay eggs which result in further larvae infestations of the wheat plants.

The methods of control are to plow under infested stubble, to destroy stands of volunteer wheat, and to delay the planting of winter wheat in the fall until after the fall brood has emerged and the flies have laid their eggs and died.

In states where the growing of winter wheat is extensive, the state experiment station or other agency provides information on the safe dates for planting wheat to escape hessian fly infestation.

Wheat Jointworm. This insect usually passes the winter in the pupal form in the galls or swellings, resulting from their infestations of the wheat straw. In the spring the adult insects emerge, mate, and the females deposit eggs within the wheat stems, usually just above the lower nodes or joints. The maggots which hatch from the eggs feed on the sap of the plant. Excessive growth or swelling in the stem takes place at the point of infestation. The maggot remains in the gall until autumn and then enters the pupa stage.

The chief methods of control are to plow the wheat stubble thoroughly soon after harvest or to burn the straw and stubble.

Other Insects. Armyworms, grasshoppers, wheat stem sawflies, and false wireworms are some of the other insects which are troublesome in connection with growing wheat. Stored wheat is often attacked by the granary weevil, the cadelle, the angoumois grain moth, and the Indian-meal moth. The second group of insects is controlled largely by fumigating the grain in the bin.

Botanical Classification and Characteristics of Wheat. The common types of winter and spring wheat grown in the United States belong to the grass family of plants and to a particular classification known as *Triticum vulgare.* On the west coast region *T. compactum* or club wheat is produced. *T. durum,* often referred to as macaroni wheat, is largely grown in the Dakotas, eastern Montana, and western Minnesota.

Wheat is an annual plant having a summer annual form known as spring wheat, and a winter annual form known as winter wheat. The roots of the plants are fibrous. The stems and leaves are of the general grass type. The flowers of wheat occur in units called spikelets, arranged in a rather compact form along a rachis to form a spike or head. The primary parts of a wheat flower consist of three stamens and a single ovary with two feathery stigmas. Common wheat under ordinary conditions is self-pollinating. Durum wheat cross pollinates to a large extent.

Origin and History of Wheat. The following information is adapted from the 1936 Yearbook of Agriculture (176). According to the facts presented, carbonized grains of wheat have been found in archaeological findings dating back about 6000 years. Greek writers wrote about wheat as a cultivated plant. Varieties of our common bread wheats were first grown extensively in northern Europe. Varieties of club wheat were grown in Spain and in parts of southern Europe. Durum wheats were first grown in the Mediterranean countries, southern and eastern Russia, and Asia Minor. In the United States, the first plantings of wheat were made by the colonists in the early years of the seventeenth century.

The first method of wheat improvement was to introduce new varieties. Some of the wheats introduced over one hundred years ago are still being grown.

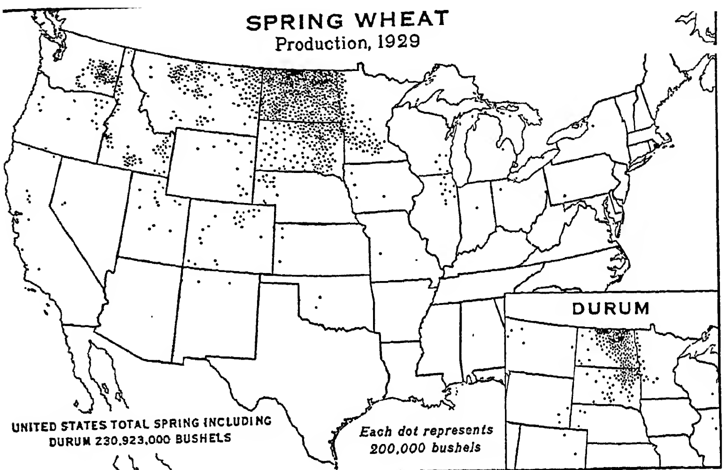
Early in the nineteenth century, the second method, that of making selections from field mixtures and hybrids which occurred under field conditions, came into use. An example is the variety Fultz, selected by Abraham Fultz, a farmer of Mifflin, Pennsylvania, in 1862.

Plant-breeding practices in wheat improvement were begun by farmers interested in such work about 1870. The variety Fulcaster, as an example, was the result of a cross between Fultz and Lancaster varieties made by S. M. Schindel of Hagerstown, Maryland, in the year 1886.

With the establishment of agricultural experiment stations, largely dating from the time of the Hatch Act passed in 1887, the work of wheat improvement has been carried on in these institutions.

Varieties. There are a very large number of varieties of wheat grown in the United States. Information as to varietal recommendations by states may be found by turning to Table 51 in the Appendix. Rather complete information as to varieties is also to be found on pages 267 to 296 of the 1936 Yearbook of Agriculture. The Yearbook

provides particularly interesting information as to the recommended commercial varieties that are of unknown origin, or that were developed by selection or hybridization and first distributed in the United States by farmers, seedsmen, and private breeders. The 1936 Yearbook also provides information as to commercial varieties that were introduced or developed and first distributed in the states by state and federal agricultural experiment stations.



(U.S.D.A.)

FIG. 90.

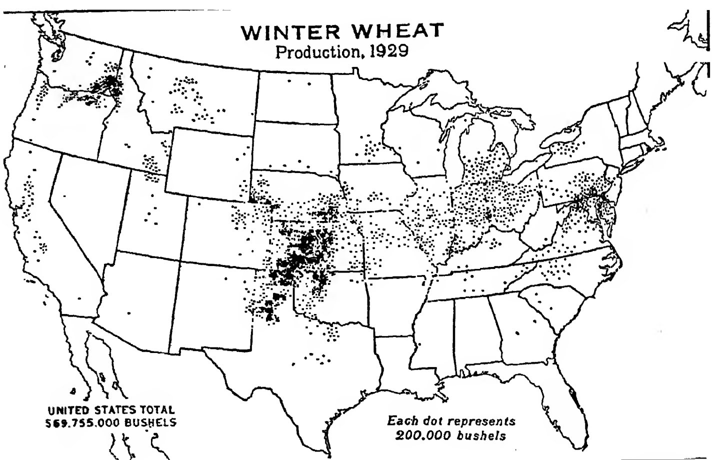


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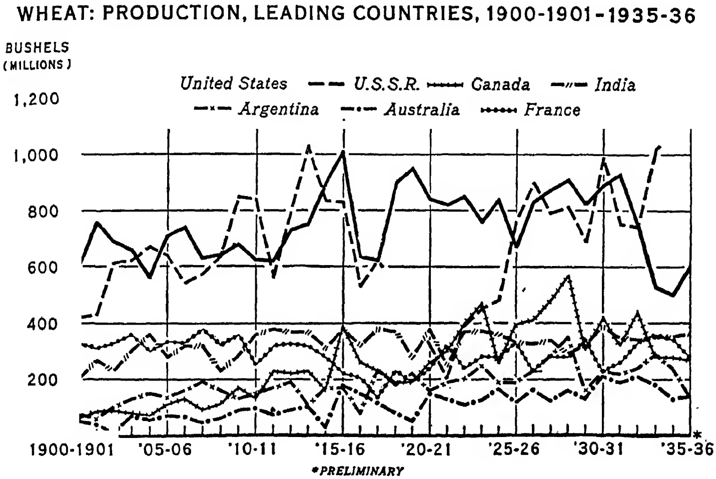
FIG. 91.

Composition of Wheat. As indicated in Table 49 of the Appendix, wheat grain contains about 12 per cent crude protein and 71 per cent carbohydrates. Hard winter and Hard spring wheats contain the highest percentages of protein and are used in the manufacture of bread flours having a high gluten content. Vitamin B, vitamin E, and another vitaminlike material are found in wheat germs.

Wheat-Production Areas of the United States. The areas in which wheat is produced is well illustrated in Figs. 90 and 91.



(*U.S.D.A.*)

FIG. 92.

Wheat-Production Statistics. Some estimate of wheat production in various countries may be gained from an inspection of Fig. 92.

A statistical summary of wheat production and related facts is presented in Table 21.

For further statistical analyses pertaining to wheat production, the reader is referred to the volume, Agricultural Statistics, published annually by the United States Department of Agriculture.

Market Standards for Wheat. According to the "Handbook of Official Grain Standards" of the United States (168), wheat is divided into seven classes, as follows: Class I, Hard red spring wheat; Class II, Durum wheat; Class III, Red durum wheat; Class IV, Hard red winter wheat; Class V; Soft red winter wheat; Class VI, White wheat; and Class VII, Mixed wheat.

TABLE 21 *

WHEAT: ACREAGE, PRODUCTION, AND VALUE, 1934–1940

Year	Acreage Harvested	Average Yield per Acre	Production	Season Average Price per Bushel Received by Farmers	Farm Value
	(1000 acres)	(Bushels)	(1000 bushels)	(Cents)	(1000 dollars)
1934	43,400	12.1	526,393	84.8	446,367
1935	51,229	12.2	626,344	83.2	521,315
1936	48,863	12.8	626,766	102.6	643,183
1937	64,422	13.6	875,676	96.3	842,874
1938	69,869	13.3	931,702	56.1	522,639
1939	53,482	14.1	751,435	69.2	519,651
1940	53,503	15.3	816,698	67.0	547,084

* United States Department of Agriculture, Agricultural Statistics, 1941.

Table 22 presents the grade requirements for the Hard red spring wheat class and subclasses. Somewhat similar tables and additional information concerning the various classes and grades of wheat are to be found in the Handbook of Official Grain Standards (168).

Wheat Research. Senate Document 65 (130) provides a survey of the present and proposed research in connection with wheat. For rather complete details, reference should be made to the document. The following material has been selected from this publication.

1. Genetic and breeding studies to develop resistance to black stem rust, bunt or stinking smut, and other diseases and insects; to hasten date of maturity; to improve cold resistance or winter hardiness in fall-sown or winter wheats; and to produce strong, high-gluten bread wheats and soft starchy wheats for pastry and cake baking; with parallel studies of the effects of genetic characteristics, plant diseases, insect infestations, and frost damage on the composition and technological properties and characteristics of wheats.

2. Investigations of environmental influences upon the composition of wheat, including: available moisture from rainfall or irrigation; effect of soil nutrients, their concentration, and the time and manner of their application to the soil; and temperature and related climatic variables.

3. Cultural and harvesting studies in their relation to control of insect pests, and to composition and quality of wheat, including Combine harvest-

TABLE 22 *

CLASS I—HARD RED SPRING WHEAT

(Grade Requirements for (a) Dark Northern Spring, (b) Northern Spring, (c) Red Spring)

Grade	Minimum Test Weight per Bushel	Maximum Limits					
		Damaged Kernels (Wheat and Other Grains)		Foreign material		Wheats of Other Classes	
		Total	Heat-damaged	Total	Matter except other grains	Total	Durum and/or Red Durum
	(Lb.)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)
1 heavy †, ‡	60	2	0.1	1	0.5	5	2
1 ‡	58	2	.1	1	.5	5	2
2 ‡	57	4	.2	2	1.0	10	3
3	55	7	.5	3	2.0	10	5
4	53	10	1.0	5	3.0	10	10
5	50	15	3.0	7	5.0	10	10
Sample grade	Sample grade shall include wheat of the subclass Dark northern spring, or Northern spring, or Red spring, which does not come within the requirements of any of the grades from 1 Heavy to 5, inclusive; or which contains more than 16 per cent of moisture; or which contains inseparable stones and/or cinders; or which is musty, or sour, or heating, or hot; or which has any commercially objectionable foreign odor except of smut or garlic; or which contains a quantity of smut so great that any one or more of the grade requirements cannot be applied accurately; or which is otherwise of distinctly low quality.						

* United States Department of Agriculture, Handbook of Official Grain Standards.

† Applies to each of the subclasses Dark northern spring, Northern spring, and Red spring.

‡ The wheat in grades 1 Heavy and 1 of this class may contain not more than 7 per cent, and the wheat in grade 2 of this class may contain not more than 10 per cent, of shrunken and/or broken kernels of grain and other matter that will pass through a 20-gage metal sieve with slotted perforations 0.064 inch wide by $\frac{3}{8}$ inch long.

ing under varied climatic conditions; relation of stage of maturity at time of harvest and of various methods of handling summer fallow to composition and technological properties; effect of previous crops, particularly of legumes, upon the composition and properties of succeeding wheat crops; and effect of damaged, shrunken and broken kernels, and of foreign material, upon the composition and properties of bulk wheat.

4. Wheat-storage investigations, such as: influence of relative soundness or freedom from damage, foreign materials, moisture content temperature, ventilation, size of kernel, control of insect pests, and other factors upon the respiration and keeping qualities of the stored grain; and relation of stored-grain pests, including fungi, bacteria, insects, and mites to bulk temperature, to the destruction of grain substance, and to the modified composition and properties of infected wheat.

In addition, research is being carried on under the following categories: milling of wheat; dough studies; baking investigations; specialty food products; by-products.

RYE

Although rye does well on relatively poor soils in comparison with some of the other grain crops, yet it responds well to the use of improved practices.

Grow the Highest Yielding Variety. Rye is naturally an open-fertile, wind-pollinated plant; hence commonly grown varieties show greater variation and more numerous mixtures than the common varieties of other small grains, which are close-pollinated. During recent years, marked improvements have been made by plant breeders, in the leading rye-growing states, in the yielding ability and adaptation of rye varieties.

In Michigan, the Rosen rye is an outstanding example of a great improvement in rye growing, owing to the development and widespread distribution of a superior variety. This variety was developed by the late plant breeder F. A. Spragg, from a small sample received in 1908 through Mr. J. A. Rosen, a Russian student, who secured the sample from his home farm near Riga, Russia. This sample was tested at the Michigan Experiment Station, in comparison with other ryes, and found to show great superiority. In 1912, a bushel of Rosen from the college increase plots was placed in the hands of a Jackson County farmer, a member of the Michigan Crop Improvement Association, who planted it on an acre of ground away from other rye. This acre yielded 45 bushels and gave the first substantial start to the distribution of this rye. The Rosen outyielded common ryes 10 to 15 bushels per acre in many instances in Michigan. It rapidly increased in acreage. Large supplies of pure seed were made available through the activities of the Michigan Crop Improvement Association. At present the Rosen or near-Rosen occupies practically all the Michigan rye acreage, and this variety has become important in the rye-grow-

ing states of the northern Corn Belt, in New York, and on the lighter soils of southern Wisconsin and Minnesota.

In Wisconsin, the Wisconsin pedigree rye is recognized as the leading variety. This is a development of the plant-breeding work of the Wisconsin Experiment Station. In Virginia, Tennessee, and the Cotton Belt, the Abruzzi rye is generally grown.[1]

Clean Seed with Fanning Mill and Test Germination. Seed rye should be thoroughly cleaned with a good fanning mill before planting. If ergot is present, other seed should be secured. While rye seed that has been properly stored usually germinates well, nevertheless it is a good practice to test the germination of seed before planting so as to regulate the planting rate or to get other seed if necessary.

Plant Sufficiently Early on a Well-Prepared Seed Bed. Rye can be planted safely one, two, or more weeks after the usual planting date for wheat. Higher yields and better results can be secured, as a general rule, by planting about the same time, or only a few days later, than wheat is planted. Planting too late in the fall will result in decreased yields. Rye should be planted at the rate of 1 bushel to 6 pecks for Rosen, and from 6 pecks to 2 bushels for most other varieties, per acre. Drilling gives higher yields than broadcasting. Rye should be planted at a depth of 1 or 2 inches—1 inch on heavier soils and 2 inches if soils are light in texture.

Use Fertilizers Where Profitable. Fertilizers are not used as generally on rye as on other grain crops. Nevertheless, rye responds remarkably well to the proper use of commercial fertilizers and of manure. The use of 200 to 300 pounds of superphosphate per acre will increase markedly the yield of rye and will improve its quality. Manure, applied during the preparation of the seed bed or in the fall or early winter, increases rye yields to a considerable extent, particularly on light soils.

Harvest When Properly Mature; Cure and Thresh. Rye should be harvested as soon as possible after it matures. If it is allowed to become overripe, large losses, due to lodging and to the shattering of kernels, may occur. Rye is usually cured in the field in open shocks.

Rye straw often brings a good price on eastern markets. If the straw is to be sold for the purpose of manufacturing mats, bundle cases, etc., care should be taken in handling the crop to prevent the breaking of straw; and the crop should be threshed by a separator,

[1] For varietal recommendations by states, see Table 51 of the Appendix.

equipped with a belt-straw conveyor, rather than by the blower type of straw harvester and stacker.

As soon as threshed, the rye should be stored in properly constructed, well-ventilated bins, or else should be sold immediately. If damp when threshed, it should be laid on a barn floor and kept stirred until dry.

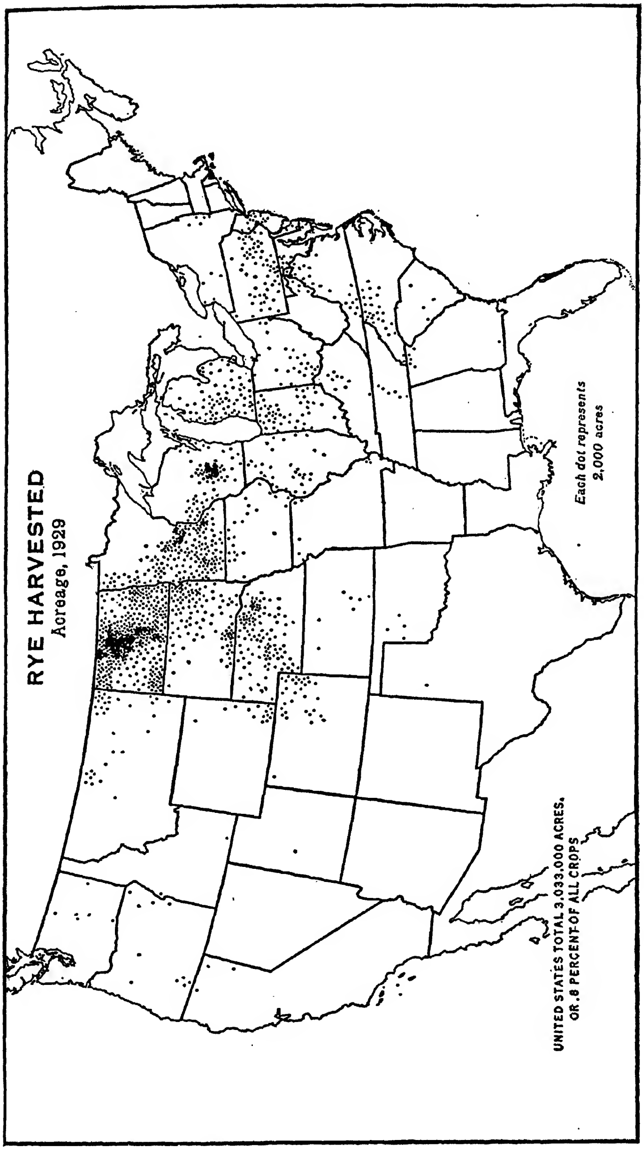
Ergot in Rye. Ergot frequently causes large losses in rye. This fungus disease causes the formation of large, purplish-black, finger-like bodies which replace the kernels. Ergot-carrying rye is poisonous to human beings and livestock and may cause abortion in pregnant animals.

Only ergot-free seed should be planted. However, seed which carries ergot bodies may be planted if the seed is more than one year old, because the ergot bodies lose their vitality after this period. Ergot bodies can be removed by making a 20 per cent solution of common salt and water, pouring the rye in, and stirring and skimming off the ergot bodies. Add salt and water until the point is reached where rye kernels sink and ergot bodies float.

Botanical Classification and Characteristics of Rye. Rye, *Secale cereale,* belongs to the grass family of plants. The stems, leaves, roots, and flowers are quite similar to the corresponding parts of wheat, oats, and barley. In comparison with these crops, however, the stems of rye are longer, tougher, and more slender. Moreover, rye is regularly cross-fertilized which is in contrast to the other grain crops mentioned.

Origin and History of Rye. The earliest historical record concerning rye is that of its use by the Romans in the first century B.C. It was grown at an early date in the regions which now constitute Spain, where it shows a tendency to perennial growth.

Areas of Rye Production. Figure 93 indicates the areas of production. The northern states and Canada are best adapted to the growing of rye for grain purposes. In the Corn Belt and northern states it is widely used as a cover crop, as a pasture crop, and for green manuring. Rye is somewhat hardier than winter wheat and can be planted later in the fall, with assurance of a good crop. It also gives better results than wheat on soils of less than average fertility. Winter rye is grown principally since spring rye yields much less under similar conditions.


RYE HARVESTED
Acreage, 1929
Each dot represents 2,000 acres
UNITED STATES TOTAL 3,033,000 ACRES,
OR .8 PERCENT OF ALL CROPS

(U.S.D.A.)

FIG. 93.

Rye-Production Statistics. The average annual production of rye for the period 1927 to 1936 was 30,186,000 bushels. The production in the year 1938 was 49,107,000. In that year North Dakota led with a production of 12,974,000 bushels, followed by South Dakota, 10,176,000 bushels; Minnesota, 9,846,000 bushels; Nebraska, 4,796,000 bushels; Wisconsin, 4,290,000 bushels; and Michigan, 1,552,000 bushels.

CHAPTER XIX

OATS AND BARLEY

OATS

The production of oats is important in many sections of the United States in providing a feed crop and a crop which may be sold for cash. This crop also finds a place on many farms because of its suitability in crop rotations.

Climatic and Soil Factors in Oat Production. Although oats are grown over a wide area in the United States, the best locations for oat production are those having a cool, moist climate.

Well-drained soils, ranging in *p*H from 5.2 to neutrality, having moderate supplies of nitrogen, phosphorus, and potash, are suitable for oat production. The soils on which oats are grown to the largest extent are the Corn Belt soils of Illinois, Iowa, and southern Minnesota, with extensions into the gray-brown podzolic regions of Minnesota, Wisconsin, Michigan, Ohio, and New York, and west into the chernozem belt. A detailed description of these soils is to be found in the 1938 Yearbook of Agriculture.

Oats in Rotation. The oat crop is typically found in crop-rotation plans. Throughout the Corn Belt, the oat crop is very commonly included in the rotation and, when it does occur, it is practically always found immediately following the corn crop. Corn, oats, clover or corn, oats, wheat, and clover are typical Corn Belt rotations. In dairy regions which are largely north and northeast of the true Corn Belt, the oat crop is included in such rotations as: corn, oats, clover; corn, oats, wheat hay; corn, oats, hay pasture.

Fertility Requirements. In rotations which include oats, it is common to use manure and fertilizers when needed in connection with the corn, wheat, grass, or clover crops included in the rotation. If these crops are properly cared for, there is no particular need for providing the oat crop with direct applications of fertilizers or manure. The oat crop does better under conditions that supply moderate quantities of nutrients. Excessive quantities of nitrogen are detrimental. On soils high in fertility, it is well to produce two crops of corn before oats,

as a means of reducing fertility amounts to levels satisfactory for oat production.

Seed Qualities. It is essential to use oat seed of a variety which is well adapted to the soil and climatic conditions and to the purpose for which the crop is being grown. Early oats, for example, are better than late oats as a companion crop. Well-filled, plump seed, free

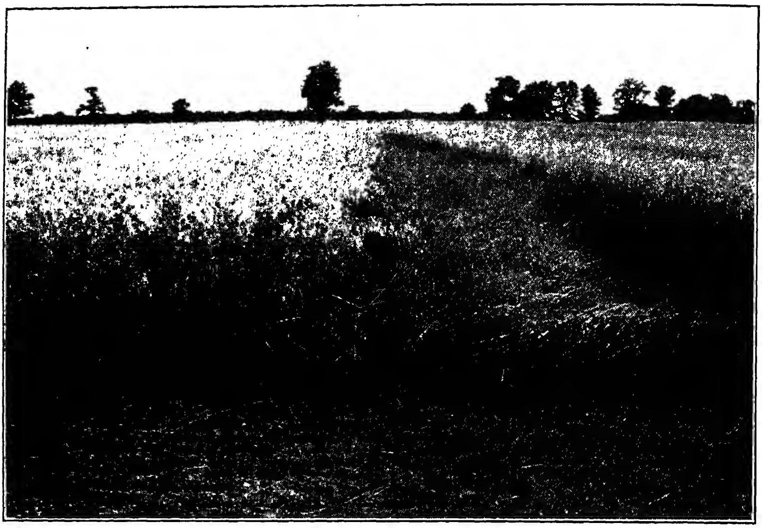


FIG. 94. A variety test in Michigan reveals that a certain variety of oats is unadapted because of a tendency to lodge. (*Michigan Agricultural Extension Service.*)

from mixtures, diseases, weed seeds, dirt, and trash, should be used for seeding purposes.

Seed-Bed Preparation for Oats. Since spring-grown oats usually follow corn or some other cultivated crop in the rotation, it is common practice to disc the soil as early in the spring as possible. At the Ohio Station at Wooster (56), investigation revealed that thorough discing of corn stubble resulted in much better yields than when oats were planted with no preparation, and that plowing did not increase sufficiently the yields over discing to recommend the practice.

Under conditions in western Oregon (63), it is recommended that the seed bed for spring-sown oats be plowed as early as possible. If plowing must be delayed, the land should be disced early and then plowed. Thorough cultivation of the spring seed bed is recommended.

Different conditions will require different methods of soil preparation for spring-sown oats, but the object in any event is to prepare a seed bed that is compact, that permits the drilling or broadcasting of the seed under favorable conditions for germination, and permits the seeding of oats at an early date.

According to the Oregon Station (63), the preparation of the seed bed for fall-sown oats in western Oregon may be accomplished by discing if the oats are to follow a row crop, such as corn, beans, or potatoes. Plowing usually is necessary where oats are to follow fall wheat, barley, or any other uncultivated crop that has stood through the winter.

Seeding Oats. Tests in various states indicate that spring-sown oats should be planted early. The Ohio Station at Columbus (56) reports that the yield of oats decreases 1 to $1\frac{1}{2}$ bushels for each day's delay in planting after early April. At Wooster, Ohio, the earliest dates of seeding used in the tests produced the greatest yields.

According to the Michigan Station (38), the seeding of oats should be done as early in the spring as possible. Early seeded oats take advantage of the cool growing period, normally escape hot, dry periods at heading and filling time, and are more likely to escape stem-rust infections.

As to the rate of planting spring oats, the Michigan Station (38) recommends about 8 pecks. Ohio Station investigations (56) at Wooster indicate that the best yields result from the use of 9 to 11 pecks of seed, while at Columbus a rate of 8 pecks has been found satisfactory.

Winter oats are recommended by the Arkansas Station (95) because they exceed spring oats in yield, even when an occasional crop entirely is lost by winter killing, and they have the added advantage of serving as a winter cover and pasture crop. The findings of this station indicate that late September is the optimum date for planting winter oats on the high elevations of the state, and that the dates October 1 to 10 are suitable in the Cotton Belt sections. Tests indicate that a rate of 7 to 9 pecks is sufficient for winter oats. Under western Oregon conditions (63), the dates October 10 to 20 are recommended for seeding, and the rate of seeding is about 10 pecks per acre. Results at the Mississippi Station (86), covering twelve years of experimental work, indicate that oats should be planted at the rate of 10 pecks per acre on or near the date of October 15. The variety red rust proof was used in these tests.

Harvesting. Oats are commonly cut with a binder and placed in long, narrow shocks to promote the drying out or curing of the grain.

The best colored oats are secured when cutting is done, just at the time the oats have matured.

More and more oats, however, are being harvested by means of the combined harvester-thresher. Because oats have a tendency to

FIG. 95. The small combined harvester-thresher is being used more frequently for harvesting small grain. (*J. C. Allen and Son, West Lafayette, Indiana.*)

lodge after reaching maturity, it is quite common to cut the crop, leave it in the windrow until dry, and then pick it up with a combine.

Botanical Classification and Characteristics of Oats. *Avena sativa,* common, spreading-panicled oats; *A. orientalis,* side-panicled oats; *A. nuda,* a form of oats which is hull-less when threshed; and *A. byzantina,* red oats, constitute the oats generally grown in the United States.

Most varieties of oats are summer annuals while a few varieties are winter annuals. The roots of oats are similar to wheat in having a

dense, fibrous growth. Most of the root growth is found near the surface of the soil, but portions of the root system may penetrate several feet into the soil.

The stems of oats are hollow, somewhat larger and softer than those of wheat, and grow 2 to 5 feet in height. Each plant produces from three to five stems. The leaves of oats are broader and more abundant than those of wheat.

The spikelets of oats are arranged in a spreading-panicle form, or are borne on rather erect branches on one side, rather close to the main stem or axis of the panicle. This arrangement gives rise to the name "side oats" and to other names implying this formation in growth habit.

The oat flower, as a rule, is self-fertilizing.

Origin and History of Oats. The common, cultivated forms of oats appear to have been derived from *A. fatua,* the common wild oat, and from red oats from *A. sterilis,* the wild red oat.

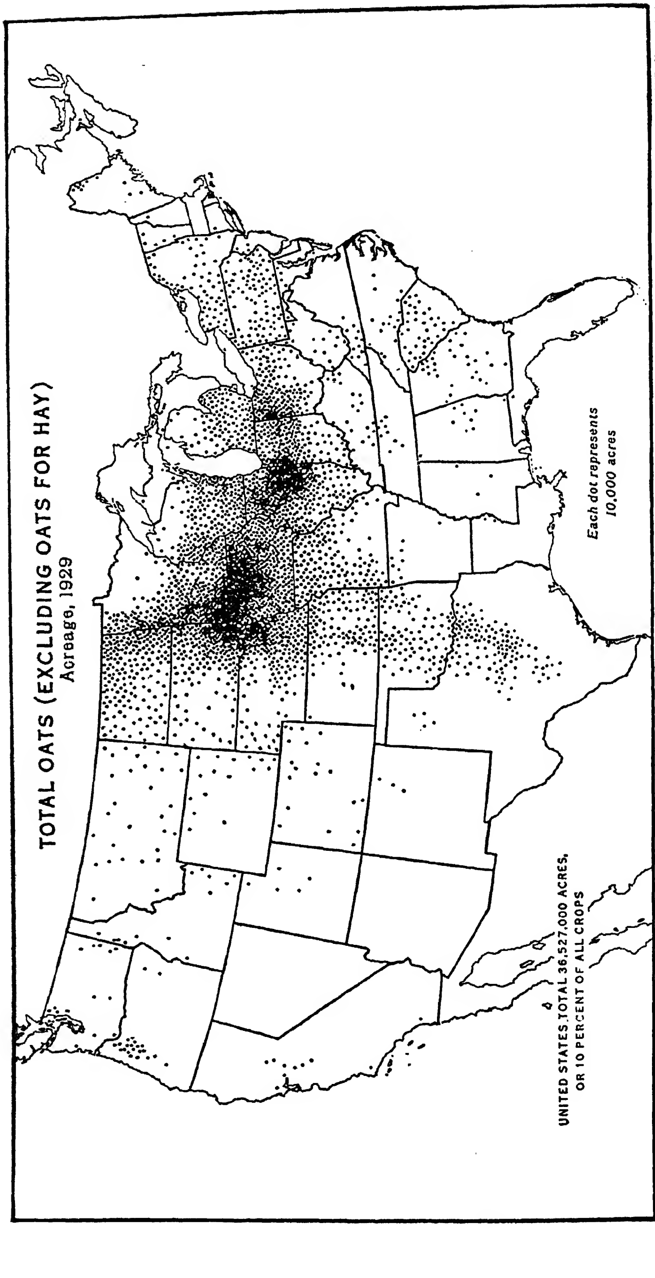
There seems to be little definite information about the time and place in the origin of the cultivated forms of oats. It appears that cultivated varieties of oats came from areas embracing the temperate regions of eastern Europe and western Asia. Early Christian Era writers describe the common oat as being grown by Europeans for grain, while the red-type oat was grown for fodder in Asia Minor. The common red oat is now grown in the Mediterranean region.

Varieties of Oats. Although there are a large number of oat varieties, many of them may be classified according to certain varietal types. The Fulghum oat, which originated on the farm of J. A. Fulghum in Georgia, with its strains is the most important varietal type of red oat grown in the United States. Kherson and Sixty Day oats represent the most important early common oats. Many selections have been made from these varieties. Early oats are of particular use in Corn Belt crop rotations.

Examples of midseason varieties with white grains are: Maine 340, a leading variety in Maine; Wolverine, a highly productive variety in Michigan; Ithacan and Upright, grown on New York dairy farms; Wayne oats in Ohio; Wisconsin Wonder and Forward in Wisconsin; and Colorado 37, commonly used for growing under irrigation.

Some varieties of winter oats grown in Virginia, North Carolina, and Arkansas are Lee, Support, and Coker Norton 3.

The section of the 1936 Yearbook of Agriculture devoted to Superior Germ Plasm in Oats, by T. R. Stanton (176), provides excellent information pertaining to the development of oat varieties.


TOTAL OATS (EXCLUDING OATS FOR HAY)
Acreage, 1929
Each dot represents 10,000 acres
UNITED STATES TOTAL 36,527,000 ACRES, OR 10 PERCENT OF ALL CROPS

(U.S.D.A.)

FIG. 96.

Varietal recommendations are to be found in Table 51 of the Appendix.

Composition of Oats. Oats contain about 60.7 per cent carbohydrates, 12.5 per cent crude protein, 4.4 per cent fat, and 11.2 per cent crude fiber. The fiber content is rather large because of the oat hulls which are included in the analyses of the grain. Oats contain more protein than does corn.

The composition of oats may be compared with other grains by referring to Table 49 in the Appendix.

Oat-Production Areas. The areas in which oats are produced is well illustrated by Fig. 96.

Oat-Production Statistics. Facts as to oat production in the United States is presented in Table 23.

TABLE 23 *

OATS: ACREAGE, PRODUCTION, AND VALUE, 1934 TO 1940

Year	Acreage Harvested	Average Yield per Acre	Production	Season Average Price per Bushel Received by Farmers	Farm Value
	(1000 acres)	(Bushels)	(1000 bushels)	(Cents)	($1000)
1934	29,455	18.4	542,306	48.0	260,560
1935	39,831	30.0	1,194,902	26.3	314,579
1936	33,370	23.5	785,506	44.9	352,614
1937	35,256	32.9	1,161,612	30.1	350,003
1938	35,661	30.0	1,068,431	23.7	253,455
1939	32,968	28.4	935,942	31.1	290,922
1940	34,847	35.5	1,235,628	29.1	359,819

* United States Department of Agriculture, Agricultural Statistics, 1941.

The states most prominent in oat production, listed according to their 1937 production in bushels, are: Iowa, 271,998,000; Illinois, 166,-302,000; Minnesota, 165,321,000; Wisconsin, 78,558.000.

Utilization of Oats. Oats are an important feed for all classes of livestock. Most of the oats produced are used for feed purposes. Less than 3 per cent of the oats crop is used in the manufacture of breakfast food. Furfural is being produced from the oat hulls that are derived from the manufacture of rolled oats and oat meal. Furfural

is used in the manufacture of synthetic resins, from the purification of wood rosin, and in the refining of lubricating oils.

Market Standards for Oats. The market standards for various grades of oats are to be found in the Handbook of Official Grain Standards (168).

BARLEY

Barley is grown primarily in the North Central States, California, and Canada, where it is an important crop. It is the chief grain feed of regions north of the Corn Belt. In the northern portions of the Corn Belt, barley is coming into use more and more as a feed for the early fattening of hogs.

Climatic, Soil, and Fertility Requirements in Barley Production. Barley is primarily a cool-weather crop, grown in northern states.

According to the 1938 Yearbook of Agriculture (178), the chief centers of barley production lie in the areas represented by the Barnes, Beardon, and Fargo soils of the eastern Dakotas and of western Minnesota; the Carrington, Tama, and Clinton soils of southeastern Minnesota; the Kewaunee and Miami soils of eastern Wisconsin; the Clarion, Carrington, and Miami soils of northeastern Illinois; the Keith, Weld, Bridgeport, and Tripp soils of northwestern Kansas, southwestern Nebraska, and eastern Colorado; and the Yolo and Capay soils of the Sacramento Valley of California. Most of these soils vary from black loams of rather heavy texture, through dark and grayish-brown silty loams, to dark, grayish-brown sandy loams.

Barley in Rotations. The South Dakota Station (81) reports that barley grown at Brookings in three different rotations yielded, as an average over an eighteen-year period in the respective rotations, as follows: corn, barley, sweet clover, 38.4 bushels; corn, barley, field peas, 42.0 bushels; barley, millet, wheat, 29.2 bushels. These yields may be compared to 31.6 bushels per acre for continuous barley. The highest yields were obtained after corn in those rotations, including a cultivated and a leguminous crop.

The Kansas Station (156) reports that spring barley is well adapted to a rotation of wheat, sorghum or corn, and barley, or to a rotation of sorghum, barley, fallow, and wheat.

At the Oregon Station, Harney Branch (65), barley under irrigation as a nine-year average yielded as follows: 82.0 bushels in a peas, potatoes, barley rotation; 77.3 bushels in a peas and oats, potatoes, barley rotation; 76.9 bushels in a sunflowers, peas, barley rotation; 48.8

bushels in a peas and oats, barley rotation; 35.7 for continuous barley.

In many of the Wisconsin, Illinois, and Minnesota areas in which it is grown, barley follows corn in the rotation.

Barley-Seed Quality. When barley is grown for sale as malting barley, it is particularly essential to use a pure variety of seed, adapted to malting purposes, unmixed with other grains, high in germination, and free from disease. These same general characteristics also contribute to efficient production regardless of the use to which the crop is to be put.

Seed-Bed Preparation for Barley. When spring-seeded barley follows a cultivated crop, such as corn, the usual practice is to double disc and harrow the soil in preparing the seed bed. The South Dakota Station (81) reports that where spring barley follows other grain it is essential to plow either in the fall or in the spring, depending upon conditions. Under Kansas (156) conditions, probably the best seed bed for spring barley can be prepared on corn or sorghum land by giving a light cultivation with a one-way plow, followed by a packer.

In western Oregon (65), the seed bed for all barley should be plowed as early in the fall as practicable. The ideal seed bed for fall barley is one that is well worked but left in a slightly cloddy condition. If fall barley is to follow a cultivated crop, such as corn, potatoes, or beans, the seed bed may be easily prepared by discing.

Under Maryland (136) conditions, it is recommended that the seed bed for winter barley be prepared by early plowing rather than discing because the plowing turns under disease-bearing refuse. After plowing, the soil should be leveled and well compacted, with the upper 2 inches left in a loose and finely pulverized condition.

Planting Barley. Spring-sown barley is usually planted at the rate of 6 to 8 pecks per acre. Rates may vary somewhat from this recommendation, depending on conditions. It has been believed that barley should be planted after oats and wheat have been seeded in the spring, but investigations indicate that barley does better if it is planted about the same time as these crops. Best results are obtained in seeding by using a grain drill.

In regions where winter barley is used, it is planted in the fall at the rate of 6 to 8 pecks per acre. Because of the need of making a particularly good growth in the fall, it is recommended that barley be sown ten days to two weeks ahead of the normal time for planting winter wheat. Drilling seems to be the preferable method of planting.

Harvesting and Threshing Barley. Barley shatters very easily when it is ripe and the grains are very easily discolored by weathering. These facts make it necessary to use care in harvesting to reduce losses from shattering and to prevent discoloration that reduces market quality. Barley may be combined, but conditions very often occur which make the crop difficult to handle in this manner. Probably the best grade of barley is secured by cutting with a binder when barley

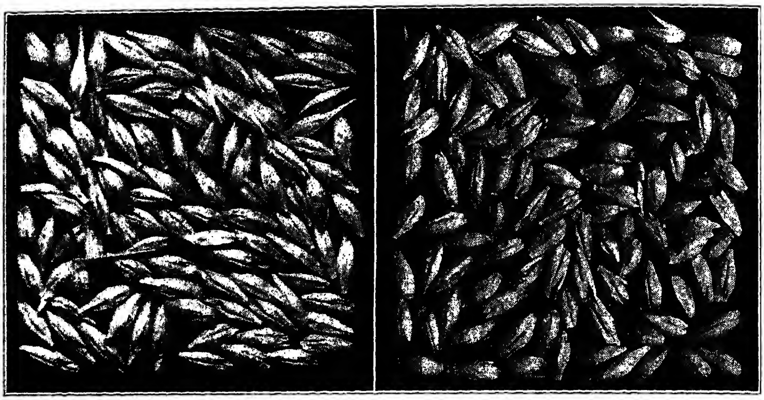


FIG. 97. The sample of barley at the left is suitable for malting purposes because the kernels are not skinned or broken, whereas the other sample of barley is unsuitable for malting purposes because of the damaged condition of the kernels. (*Minnesota Agricultural Extension Service.*)

has just reached the fully ripe stage. The crop then should be allowed to cure in well-made shocks. Threshing as soon as the crop is dry is very desirable. The threshing operation must be watched to prevent the breaking of kernels or the destruction of the hull. Skinned and broken kernels are particularly undesirable for malting purposes or for seed.

Barley Diseases. There are a number of diseases which cause rather severe losses in barley production. Loose smut, caused by the organism *Ustilago nuda,* has a life cycle much like the loose smut of wheat. The hot-water treatment appears to be the only satisfactory means of treating the seed. Another form of loose smut caused by the fungus *U. medians* may be controlled by treating the seed with mercury dust compounds. The formaldehyde or the mercury dust treatment of seed may be used to control the covered smut of barley which is caused by *U. hordei.*

Helminthosporium gramineum is the organism causing the stripe disease of barley. The disease may be controlled by treating the seed with mercury dust compounds. Barley varieties that are resistant to this disease may be used.

Scab and blight in barley are caused by the organisms *Gibberella saubinettii* and *Helminthosporium sativum*. The control of scab and

Fig. 98. Grain damaged by loose smut. This disease attacks barley and other small grains. (*Ohio Agricultural Extension Service.*)

blight may be accomplished by clean cultivation, crop sanitation, and the use of resistant varieties. Seed treatment may be of help in controlling seedling infection.

The details of the diseases affecting barley are presented in reference 35.

Botanical Classification and Characteristics of Barley. *Hordeum vulgare* and *H. distichon* are the two classifications which appear to include the common varieties of barley grown in the United States. *H. vulgare* is the common six-row barley which is often called four-row barley. The spikes give the appearance of having four rows instead of six because of the overlapping of the lateral grains of spikelets that are attached in groups of three, opposite each other on the rachis.

There are a number of common barley forms. *H. vulgare pallidum* is a white barley usually grown in the northern sections of the United States, Canada, Asia, and Europe. There are both winter and spring varieties of this barley. *H. vulgare coerulescens* is a barley having a bluish color. *H. vulgare trifurcatum* is a type of barley in which the customary awns are replaced by a three-pronged structure in the form of horns or hoods. This barley is often called hooded barley and also Nepal barley. There are both naked and hulled forms. *H. vulgare nigrum* is a black barley. *H. distichon* is a two-row barley. Only one, however, the central spikelet of the group of three spikelets on opposite sides of the rachis, is fertile; consequently two rows of kernels develop on opposite sides of the rachis. The following types of two-row barley occur. *H. distichon nutans* is a type of barley whose heads bend over or hang down when ripe. *H. distichon erectum* is a type of two-row barley with heads that are erect when ripe.

There are numerous other forms of barley which are not listed here because they appear to have little economic importance.

Barley varieties include both summer and winter annual forms. The roots of barley are fibrous and resemble the root growth of oats. The culms are hollow and usually have five to seven joints or nodes. The leaves are somewhat similar to wheat.

The inflorescence of barley is in spike form with three single-flowered spikelets attached at each joint of the rachis. In six-row types, all flowers are fertile, whereas in two-row types, the lateral flowers in each triad are imperfect or sterile. Barley is ordinarily self-pollinated, although in certain instances there appears to be some opportunity for cross pollination.

Origin and History of Barley. The general opinion seems to be that the present forms of barley are derivatives of a wild form known as *H. spontaneum.* This form of barley resembles somewhat the present two-row barleys of the *H. distichon* group.

Barley is one of the oldest of cultivated plants. Barley grains have been found in the earliest Egyptian monuments and in the remains of Lake Dwellers in southern Europe.

Varieties. There are numerous varieties of barley adapted to different regions and purposes. Barley is grown for feed or is sold for feed or for malting purposes. Recommendations as to varieties are to be found in the 1936 Yearbook of Agriculture, pages 345 and 347, and in the Appendix of this book, Table 51.

Composition of Barley. Information pertaining to the composition of barley is to be found in Table 49 of the Appendix.

According to a Wisconsin publication (91), barley for malting purposes should have a composition factor designated as *mellowness.* Mellowness is recognized by a chalky appearance of the cut barley kernel. This condition may be contrasted to a "flinty" or "steely" condition often found in barley. Mellowness is usually found when the season is cool and when ripening is not hastened. Certain varieties of barley have greater mellowness than others.

Areas of Barley Production. The areas of barley production are well illustrated in Fig. 99.

Barley-Production Statistics. The information in Table 24 provides facts on the production of barley in the United States during the past few years.

TABLE 24 *

BARLEY: ACREAGE, PRODUCTION, AND VALUE, 1934 TO 1940

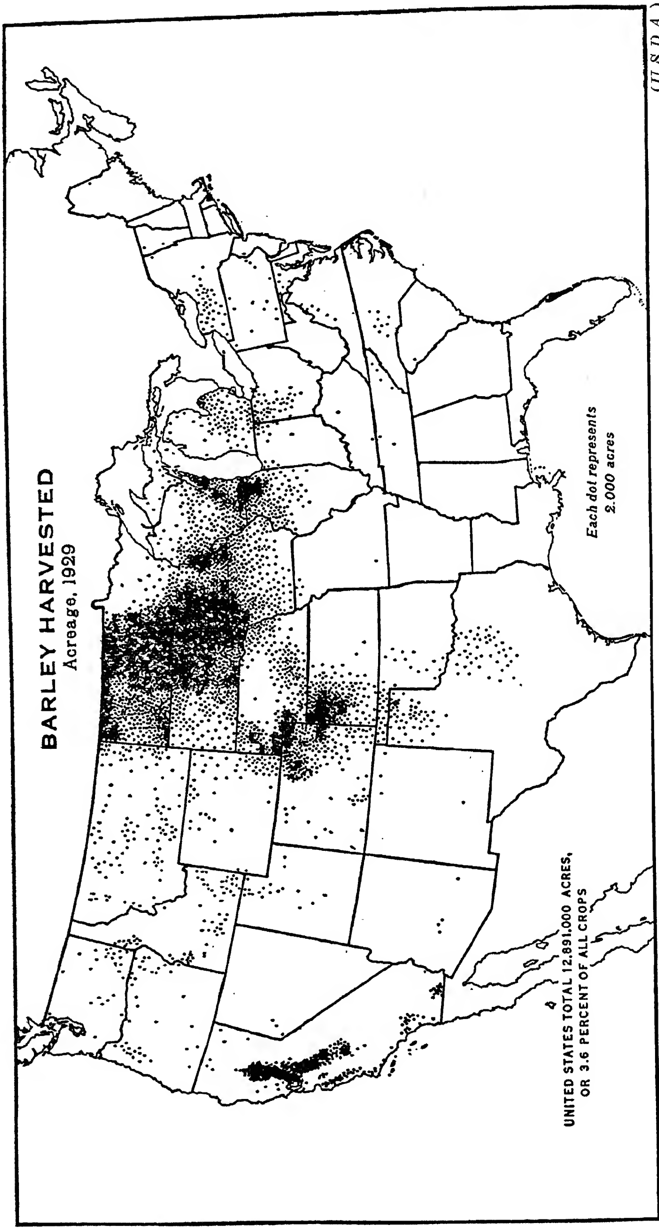
Year	Acreage Harvested	Average Yield per Acre	Production	Season Average Price per Bushel Received by Farmers	Farm Value
	(1000 acres)	(Bushels)	(1000 bushels)	(Cents)	($1000)
1934	6,553	17.8	116,680	68.6	79,994
1935	12,371	23.1	285,774	37.8	107,997
1936	8,372	17.6	147,475	78.4	115,681
1937	9,968	22.1	220,327	54.0	119,075
1938	10,513	24.1	253,005	36.6	92,609
1939	12,644	21.7	274,767	40.3	110,826
1940	13,394	23.1	309,235	38.7	119,719

* United States Department of Agriculture, Agricultural Statistics, 1941.

The states leading in barley production, in bushels, for the year 1937 are as follows: Minnesota, 51,536,000; California, 28,350,000; Wisconsin, 22,022,000; North Dakota, 21,120,000; South Dakota, 20,068,000.

Utilization of Barley. Barley is used primarily as a feed crop. It is often substituted for corn in rations for all classes of livestock. Its value as a feed is usually somewhat less than corn.

Approximately one-fourth of the annual barley crop is used for malting purposes. For this reason large amounts of barley are handled


BARLEY HARVESTED
Acreage, 1929
Each dot represents
2,000 acres
UNITED STATES TOTAL 12,891,000 ACRES,
OR 3.6 PERCENT OF ALL CROPS

(U.S.D.A.)

FIG. 99.

on the cash markets. Very small quantities of barley are prepared for human food. Winter barley is used in grain production but is also useful for pasture and cover crop purposes.

Barley Grades. Table 25 from the Handbook of Official Grain Standards (168) presents information relative to the market grades and classes of barley. Further information is to be found in the Handbook.

TABLE 25 *

CLASS I—BARLEY. CLASS II—BLACK BARLEY

(Grade Requirements for Subclass (*a*), Malting Barley, and Subclass (*b*), Barley, of the Class Barley, and for the Class Black Barley)

Grade No.	Minimum Limits		Maximum limits			
	Test Weight per Bushel	Sound Barley †	Heat-damaged Kernels (Barley, Other Grains, and Wild Oats)	Foreign Material	Broken Kernels	Black Barley ‡
	(Lb.)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)
1 §	47	95	0.1	1	4	0.5
2 §	46	93	.2	2	8	1.0
3 §	43	90	.5	3	12	2.0
4 ‖	40	80	1.0	4	20	5.0
5	35	70	3.0	6	30	10.0
Sample grade	Sample grade shall include barley of the subclass Barley, or of the class Black Barley, which does not come within the grade requirements of any of the grades from 1 to 5, inclusive; or which contains more than 16 per cent of moisture; or which contains inseparable stones and/or cinders; or which is musty, or sour, or heating, or hot; or which has any commercially objectionable foreign odor except of smut or garlic; or which contains a quantity of smut so great that any one or more of the grade requirements cannot be applied accurately; or which is otherwise of distinctly low quality.					

* United States Department of Agriculture, Handbook of Official Grain Standards.

† Any barley in grade 1 that does not come within the provisions of the special grade Blighted, may contain not more than 2 per cent of blight-damaged barley; and barley in any grade from 2 to Sample grade, inclusive, that does not come within the provisions of the special grade Blighted, may contain not more than 4 per cent of blight-damaged barley. Any barley containing more than 4 per cent of blight-damaged barley shall be graded 1, 2, 3, 4, 5, or Sample grade, Blighted, as the case may be, as provided in the specifications for Blighted barley.

‡ These specifications do not apply to the class Black Barley.

§ See special requirements for subclass (*a*) Malting Barley.

‖ Barley that is badly stained or materially weathered shall not be graded higher than 4.

Barley Research. The following, selected from Senate Document 65 (130), provides information concerning a few of the possibilities for research.

Varietal and environmental factors to determine the effect of climate, soil composition, fertilizers, diseases, insect infestation, etc., upon the quality of barley for malting purposes; the nature of the proteins; the vitamin and mineral content; the changes in the composition of barley during growth and as the result of different methods of harvesting; the quality of beer; and the food and industrial value of malt extract and syrup.

To study the heritability of the various malting quality factors so as to make intelligent use of them in a breeding program.

Storage investigations on the effect of age and the conditions of storage (including insect infestation and the use of insecticides) upon the germinating and malting quality of barley.

Studies on the malting process, e.g., the effect of (1) temperature of the water on time of steep; (2) acids, bases, and salts in steep water; (3) the use of catalysts in the germination process; (4) temperature of kilning; (5) production of sterile malt syrup and malt sugars; (6) development of high enzyme malt; and (7) production of malt flavor and dry malt extracts with minimum hygroscopic properties.

CHAPTER XX

SORGHUMS AND MILLET

SORGHUMS

There is a wide range of sorghum types grown in the United States. The following classification is from the Yearbook of Agriculture, 1936 (176).

1. Annual sorghums (*Sorghum vulgare* Pers., *Holcus sorghum* L., *Andropogon sorghum* Brot.).
   - *A*. Sorgo (Sweet or saccharine sorghum):
     Varieties: Black Amber, Kansas Orange, Sumac, Honey, Atlas, etc.
   - *B*. Grain sorghum:
     1. Milo:
        Varieties: Dwarf Yellow, Double Dwarf Yellow, Beaver, Sooner, etc.
     2. Kafir:
        Varieties: Blackhull, Red, Pink, etc.
     3. Feterita:
        Varieties: Standard, Spur, Dwarf.
     4. Durra (Egyptian corn):
        Varieties: White, Brown, Dwarf.
     5. Miscellaneous groups and varieties: Dwarf hegari, darso, Schrock, shallu, Altamont kaoliang, Ajax, Grohoma, etc.
   - *C*. Broomcorn.
     Varieties: Evergreen, Black Spanish, Scarborough, etc.
   - *D*. Grass Sorghums:
     Varieties: Sudan grass.
2. Perennial sorghum (*Sorghum halepense* (L.), Pers.):
   - *A*. Johnson grass.

GRAIN AND FORAGE SORGHUMS

Since the sorghums that are grown for grain and forage are of the most importance, the problems in their production will be given first consideration.

Soil and Climatic Factors in Sorghum Production. According to the 1938 Yearbook of Agriculture (178), the sorghums are grown

chiefly in the southern Great Plains areas under climatic conditions too dry for corn. In the winter wheat areas of Kansas, Oklahoma, and Texas, the heavier soil types are usually devoted to wheat production and the lighter types to sorghum.

The sorghums are warm-weather crops which do well under rather dry conditions. Because the germinating seeds are very sensitive to low temperatures, it is essential to plant sorghums late enough to insure warm soil conditions. It is also essential to use varieties which, when planted at a time to insure good germination, tend to flower and fill just after the usual periods of high summer temperatures, and yet mature before frost.

Varieties. There is a wide range of varieties in sorghums. Because of the climatic factors which are so important in sorghum production, and because there is a great variation in varieties as to their qualities for particular purposes, it is very important to secure the recommendations from the nearest sources as to the best adapted varieties. Varietal recommendations are to be found in Table 51 of the Appendix.

Seed-Bed Preparation for Sorghums. Poor germination, slow early growth, and unsatisfactory stands are among the greatest problems in growing sorghum. A well-prepared seed bed is of great importance in meeting these difficulties.

Since central and western Kansas is an important sorghum-growing area, a description of seed-bed preparation, adapted from a Kansas Station publication (87), may well be presented. Over a period of years, 1924 to 1931, the best yields were obtained by blank listing the land for sorghum in late fall or early spring. When done in the fall, the listed rows catch snow, and the freezing and thawing helps to increase the quality of soil tilth. As soon as weeds start in the spring, the ridges are "pulled in" or "curled in" with a curler or weeder. If an additional growth of weeds appears, the land may again be gone over with a one-way disc plow which levels the ridges further.

In eastern Kansas where the use of the lister is not essential, the seed bed for sorghum is prepared to best advantage by fall plowing, discing twice in the spring and harrowing just before planting.

Reports on seed-bed preparation in the experiment station publications of Colorado (14) and South Dakota (67) indicate that similar general methods of seed-bed preparation are employed.

Planting Sorghum. Again referring to the Kansas Station publication (87), the method of planting used in central and western Kansas is to nose out the old furrows left from blank listing with discs at-

tached to the runners of two-row planters. In addition, it is reported that the highest yields of both grain and forage are secured when plants are spaced 6 to 8 inches in rows that are 40 to 44 inches apart. Varieties which tiller vigorously produce better results if spaced from 12 to 15 inches between plants in the row. Larger yields of forage may usually be obtained by drilling rather than planting in rows.

The amount of seed to plant for sorghums varies to a large extent. The size of seed is a great factor since, for example, seed of the variety Sumac runs about 37,000 seeds to the pound, while Dwarf Yellow milo has about 12,000 seeds per pound. Further investigations have revealed that seed of high vitality planted under favorable conditions may be expected to germinate about 50 per cent less than seed planted under normal weather conditions. Experiments that have been conducted at Amarillo, Texas, as they were reported in a Kansas publication (87), with five varieties of sorghum, revealed that sorghum which germinated 95 to 98 per cent in the laboratory gave field stands from 11 to 61 per cent on different dates of planting.

According to the Colorado Station (14), row-planted sorghums in eastern Colorado require 1 to 10 pounds of seed per acre, depending upon: the type, the size, and the vitality of the seed; the condition of the seed bed; and the stand desired. If emphasis is on grain production, the plant spacing in the rows should be relatively wide, 3 to 12 inches, which will require 2 to 3 pounds of seed per acre. If fine-stemmed forage is desired, spacing should be about 1 to 3 inches, requiring 6 to 10 pounds of seed per acre. The Colorado publication states that 30 to 40 pounds per acre are required for drill-sown sorghums on the nonirrigated soils of eastern Colorado. The South Dakota Station (67) recommends 4 to 8 pounds per acre are required for Amber cane grown in rows far enough apart to permit cultivation.

It is very essential to use correct planter plates for the seed being used and to calibrate the planter accurately.

In regard to the time for planting sorghum, it is very essential to avoid low temperatures during the time of germination. The sorghums require warmer soil temperatures than corn.

Investigations reveal that the optimum date of seeding in South Dakota (67) is June 1. In western and north central Kansas, sorghum should not be planted earlier than May 20 (87). Further south, earlier planting dates may be suitable.

Cultivation of Sorghum. Thorough cultivation of the seed bed before sorghum is planted is one of the best methods of controlling weeds

and providing suitable conditions for the absorption of rain and the conservation of moisture.

According to the Kansas Station (87), when sorghum is grown in rows, the principal tillage after planting in central and western Kansas, is usually given with disc weeders, having one large disc and one shovel on each side of the row. Soil is thrown away from the plants by the discs at the first cultivation, while the shovels loosen the soil next to the plants and sometimes are set to throw a little soil to them. In the

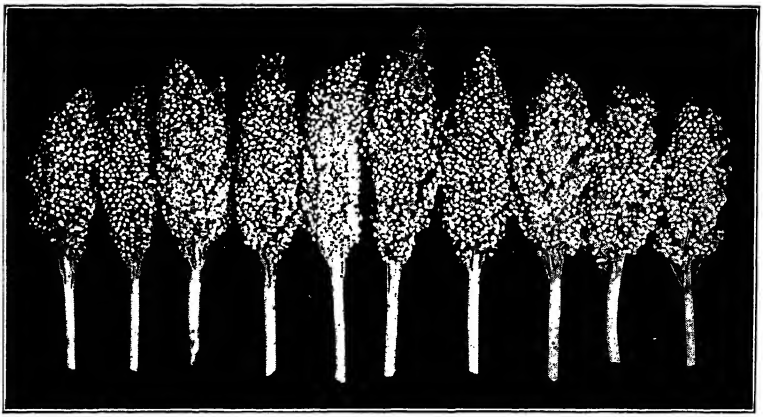


FIG. 100. The grain sorghums will produce heads such as these under conditions which prevent corn from producing satisfactorily. (*South Dakota Experiment Station.*)

second operation, the plants are usually large enough so that discs can be set to fill the furrows with soil and give support to the plants. In this operation, the shovels are set to loosen the ridges. A later cultivation should be shallow and may be given with shovel cultivators to best advantage.

Harvesting Sorghum for Grain. About 1½ to 2 acres per day may be harvested by the method of cutting sorghum heads by hand. The heads are stacked in narrow ricks to cure. Another method is to cut with a row binder or corn binder and cure in shocks. The header may be used for topping the standing crop. The heads are placed in small piles or ricks to dry. Progress has been made in developing sorghum varieties which may be harvested advantageously with a combine.

In threshing sorghum heads with the regular threshing machines or with the combine thresher, it is necessary to reduce the speed of the cylinder to 400 revolutions per minute, or about half the speed required

for threshing wheat. The balance of the machine should operate approximately at the same speed as for threshing wheat.

Storage of Sorghum Grain. Sorghum grain cannot be stored successfully unless the moisture content is below 14 per cent. Grain containing about 12 per cent of moisture can usually be stored safely. The presence of many broken kernels or of pieces of broken stalk mixed with the grain greatly increases the danger of spoilage. It is important to thresh well-cured heads under dry conditions.

Growing Sorghum for Hay. Good sorghum hay is leafy, fine stemmed, and relatively easy to cure and handle. For Kansas conditions (87), it is recommended that the seed bed be prepared in the same general manner as for grain sorghums. It is stated that sorghum planted in close drills usually makes somewhat higher yields of air-dry forage than when grown in cultivated rows, and the quality of hay is superior.

The best rates of seeding are about 30 to 45 pounds of seed per acre. Ordinarily it is advisable to cut in the soft-dough stage to secure good quality hay.

SORGO

Sorgo or syrup sorghum is grown to a small extent in various sections of the United States. The center of greatest production extends from western Virginia to eastern Colorado and southern Texas. About 300,000 acres are grown annually for syrup production, and about ten times that amount for forage purposes. A Virginia publication (55) reports that sorgo may be used for syrup, fodder, hay, soiling, and silage purposes.

The soil and fertility requirements of this crop are similar to corn. About 8 to 10 pounds of seed are planted per acre in rows, 3 to 3½ feet apart, and spaced about 4 to 6 inches in the row.

The crop is harvested in the hard-dough stage for syrup.

Sorgo was introduced into this country about 80 years ago. The crop responds well to plant-breeding experiments and techniques and it may be expected that better varieties will be developed which will extend the use of the crop.

BROOMCORN

Broomcorn is a type of sorghum which is grown to a very small extent in the United States. Commercial production areas are found in Oklahoma, Colorado, New Mexico, Kansas, Texas, and Illinois. About

325,000 acres of broomcorn are harvested annually, yielding 30,000 to 50,000 tons of fiber. The fiber or brush of this crop is used in the manufacture of brooms and whiskbrooms.

The outlook for expanding broomcorn production is not favorable. The use of brooms is being reduced by the expanding production of large and small vacuum cleaners, carpet sweepers and other equipment for cleaning. In addition, tropical fibers are being used in the manufacture of brooms, pushbrooms, or sweepers.

SUDAN GRASS

Sudan grass is identified as a grass sorghum according to the classification at the beginning of this chapter. The plant grows 4 to 6 feet tall, is upright in growth habit, and has numerous leaves. The head is in the form of a rather loose, open panicle.

The soil and seed-bed requirements are similar to corn. If broadcasted, 30 to 40 pounds of seed are used per acre, and when drilled, 20 to 30 pounds are usually sufficient. In general, it is best to plant not earlier than about two weeks after the usual corn-planting time. Plantings may be made as late as August 1, with suitable returns if conditions are favorable.

Sudan grass is particularly useful as an emergency or supplementary pasture crop. Under good conditions it will be ready for grazing in about six weeks from the time of planting. A good stand will support two or more cows per acre during the time it is available.

If sudan grass is stunted by drought or has been frozen, there is some danger that prussic or hydrocyanic acid will develop in sufficient quantities to kill livestock. When there is a vigorous growth of the grass and the grass is at least 12 inches in height, there is no danger in pasturing.

Sudan grass may be cut for hay but the coarseness of the stems make it rather difficult to cure into satisfactory hay. Sometimes sudan grass and soybeans are grown together and cut for hay purposes.

Botanical Characteristics of Sorghums. The cultivated sorghums are annual plants, having fine fibrous roots and stems that vary in height 3 to 15 feet. The stems are solid and the leaves are similar to those of corn. Suckers and branches are produced. The inflorescence is in a panicle form, varying from a compact-type head to a loose form as found in broomcorn.

The spikelets usually occur in pairs, and occasionally in groups of three. One spikelet is sessile and perfect while the other spikelet is

pedicillated and staminate. If three spikelets occur, two are usually staminate and pedicillated, although one of the pedicillated spikelets may be perfect.

In sorghums it appears that some self-pollination occurs (pollination between flowers on the same plant is frequent) and that cross-pollination is very common.

Origin and History of Sorghum. Johnson grass, *Andropogon halepensis,* which is native to tropical and subtropical parts of Europe,

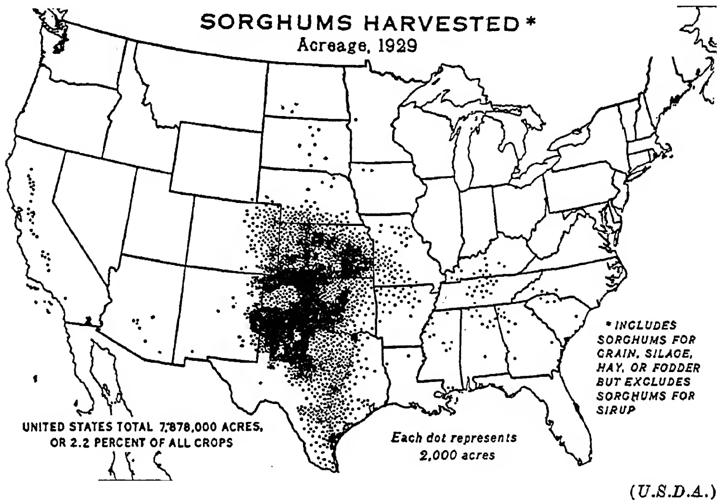


Fig. 101.

Asia and Africa, appears to be the progenitor of the cultivated sorghums.

Investigations have shown that sorghum was grown in Africa and Asia long before the time of Christ. In the United States, however, sorghum has been under cultivation only about eighty years.

The first sorgo or sweet sorghum was introduced into the United States from France in 1853 (176). The first grain sorghum was introduced many years previous to this date from West Indian sources. The grain reached the West Indies in slave ships.

Varieties. There are numerous varieties of sorghums a number of which have been listed as part of the classification at the beginning of this chapter. The varieties recommended for use in the various states are listed in the Appendix, Table 51.

Composition. The composition of various sorghums is to be found in Table 49 in the Appendix. Refer to feterita, kafir, milo, and sorgo.

Area of Sorghum Production. The area of greatest intensity in sorghum production is presented in Fig. 101.

Sorghum Production Statistics. The acreages and production of sorghum in the United States is presented in Table 26.

TABLE 26 *

SORGHUMS CUT FOR GRAIN, FORAGE, AND ALL PURPOSES: ACREAGE, PRODUCTION, AND SEASON AVERAGE PRICE PER BUSHEL RECEIVED BY FARMERS, UNITED STATES 1934 TO 1940

Year	Grain			Forage			All Purposes				
	Acreage Harvested	Average Yield per Acre	Production	Acreage Harvested	Average Yield per Acre	Production	Acreage Harvested	Equivalent Yield per Acre	Equivalent Production on Total Acreage	Price	Farm Value
	(1000 acres)	(Bushels)	(1000 bushels)	(1000 acres)	(Short tons)	(1000 short tons)	(1000 acres)	(Bushels)	(1000 bushels)	(Cents)	($1000)
1934	2347	7.9	18,521	4483	.87	3920	6830	5.9	40,225	99.8	40,133
1935	4222	12.9	54,634	5132	1.32	6757	9354	10.5	98,495	56.1	55,236
1936	2593	11.2	29,003	4285	.90	3846	6878	8.0	55,079	94.8	52,207
1937	4670	14.3	66,556	2806	1.28	3582	7476	13.1	97,679	48.8	47,656
1938	4303	14.3	61,516	3377	1.38	4649	7680	12.9	99,136	39.3	38,932
1939	4446	11.6	51,448	3632	1.16	4225	8078	10.3	83,264	56.4	46,970
1940	6039	13.5	81,234	3817	1.24	4745	9856	12.3	121,371	48.0	58,205

* United States Department of Agriculture, Agricultural Statistics, 1941.

The leading states in the production of sorghums, listed with acreage as of the year 1938, are: Texas, 3,238,000; Kansas, 1,343,000; Oklahoma, 1,211,000; Nebraska, 438,000; Colorado, 421,000; New Mexico, 350,000; South Dakota, 301,000.

MILLETS

A number of types and varieties of millet are of some agricultural importance in the United States.

Foxtail millet or *Chaetochloa italica* is an annual plant of the grass family. It is given the name foxtail because it resembles the wild green foxtail. This millet has erect or semi-erect, slender, smooth, occasionally branching stems which, under cultivation, may be from 2 to 5 feet tall.

The common varieties of foxtail millet are the German, Hungarian, and Siberian.

Foxtail millet may be drilled or broadcast at rates varying from 5 to 10 pounds on dry soils to as much as 40 pounds per acre on good land under good conditions, where it is the desire to produce fine-stemmed hay. It should be planted under warm soil and air conditions, usually between May 15 and June 15.

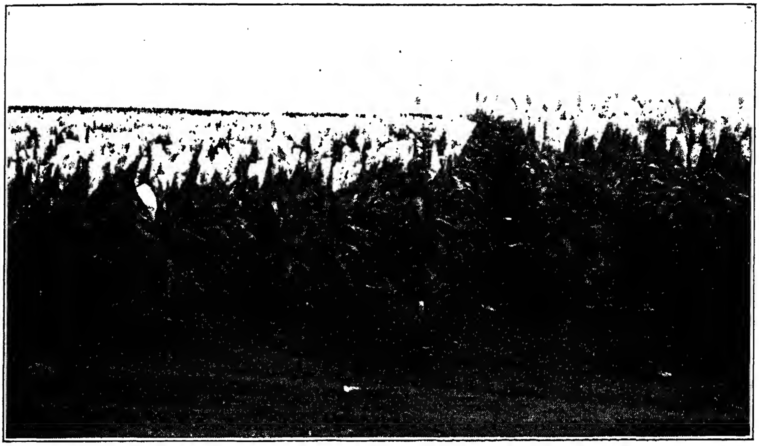


FIG. 102. The picture shows the sorghum breeding plots at the South Dakota Agricultural Experiment Station.

The chief purpose of growing this crop is to secure hay. It will produce, under average conditions, 2 to 4 tons of fair quality hay if cut between the full bloom and early dough-seed stage.

It is reported that continued feeding of foxtail millet hay to horses results in rather serious digestive troubles.

Proso millet or *Panicum miliaceum,* sometimes called hog or broom-corn millet, is grown primarily for the grain it produces. It is an annual grass, having coarse, hairy stems of an erect or semi-erect nature, 2 to 4 feet in height. The seed is produced in loose, open, drooping panicles. White French, Red Russian, and Early Fortune are some of the varieties of this millet.

Proso millet is seeded at rates varying from 30 to 50 pounds per acre and should be planted after the soil has become well warmed. From May 15 to June 15 is the usual planting period. This millet is ready for harvest when the upper half of the seed head is ripe. It is usually cut with a binder, cured in long, narrow shocks and then

threshed. It may be cut with a mower, cured in the swath, and then picked up with a combine harvester.

Another millet, *Japanese barnyard millet* or *Echinochloa frumentacea,* is of some agricultural importance as a forage crop. It is a thick-stemmed, coarse-growing millet which is related to a weed called barnyard grass. *Pearl millet* or *Pennisetum glaucum* is grown sometimes, but it appears to have little use under cropping conditions in this country.

CHAPTER XXI

GRASSES FOR HAY AND PASTURE

The *Gramineae* or grass family plants used for hay and pasture are very numerous in type and variety. An overview of their adaptation and use in the United States may be had by examining Fig. 103, which presents the main pasture regions. Table 27 furnishes information pertaining to various grasses and contains notations which refer to the regions outlined in Fig. 103.

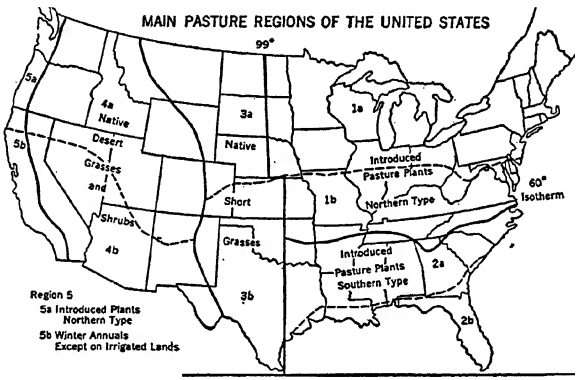


FIG. 103.

Composition. The composition of various grasses in the form of livestock feeds may be found by turning to Table 49 of the Appendix.

Information Pertaining to Specific Grasses. Since a number of the grasses are of major economic importance, additional information about them is provided.

Timothy. Timothy, *Phleum pratense,* is a perennial grass, varying from $1\frac{1}{2}$ to 5 feet in height. Timothy reproduces vegetatively as well as by seeds since corms or bulbs develop in the axils of the lower leaves. These develop in the fall of the year, and the following spring send up new shoots.

Timothy is native to northern Europe and Asia. It was known in New England as herd's grass and appears to have been introduced into

TABLE 27

INFORMATION REGARDING GRASSES FOR PERMANENT PASTURES *

Name	Climatic Adaptation	Degree of Palatability	Season of Grazing	Time and Rate of Seeding Per Acre	Soil Adaptation	Remarks
Bahia grass (*Paspalum notatum*)	section 2*b*	high	early spring to late fall	early spring; 10 to 15 pounds	sandy loam to sand	seed expensive and of low germination
Bermuda grass (*Cynodon dactylon*)	Region 2 and sections 3*b* and 4*b*	medium	late spring to early fall	early spring; 5 to 8 pounds	loams, clays, and silts	propagated to a large extent vegetatively
Brome grass or smooth brome (*Bromus inermis*)	western part of section 1*a* and sections 3*a* and 4*a*	high	very early spring to late fall	early spring or early fall; 15 to 20 pounds	practically any type	becomes sod-bound quickly
Canada bluegrass (*Poa compressa*)	Region 1 and sections 3*a* and 4*a*	high	early spring to late fall	early spring or fall; 15 to 20 pounds	almost any type	succeeds on poor soils
Carpet grass (*Axonopus compressus*)	Region 2	medium	spring to fall	early spring; 8 to 12 pounds	moist sandy or sandy loam	makes a very tight turf
Centipede grass (*Eremochloa ophiuroides*)	southern half of Region 2	medium	spring to fall	early spring use sod or stolons, no seed available	almost any type	makes a close turf and is very aggressive, crowding out weeds, legumes, and other grasses when once established
Crested wheatgrass (*Agropyron cristatum*)	sections 3*a* and 4*a*	high	very early spring to late fall	early spring; 12 to 15 pounds	almost any type	drought-resistant, easy to get a stand

Dallis grass (*Paspalum dilatatum*)	Region 2 and sections 3*b*, 4*b*, and 5*b* where irrigated	high	early spring to late fall	early spring or fall; 8 to 12 pounds	any fairly productive soil	seed expensive and often of low germination, difficult to get a stand
Johnson grass (*Sorghum halepense*)	Region 2 and sections 3*b*, also 4*b* where irrigated	high	spring to fall	early spring; 20 to 25 pounds	loams and clays	productiveness decreases rapidly when grazed, very difficult to eradicate
Kentucky bluegrass (*Poa pratensis*)	Region 1 and section 5*a*, also 3*a* and 4*a* where moisture is plentiful	high	spring to late fall	early fall; 15 to 20 pounds	sandy loams to clays of high productivity	the leading pasture grass on good soils in the North
Meadow fescue (*Festuca elatior*)	Region 1 and sections 5*a*, also 4*a* where moisture is plentiful	high	early spring to late fall	early fall; 20 to 25 pounds	loams to heavy clays	valuable in section 5*a*, of limited value elsewhere disappearing rather quickly except on heavy moist clays
Meadow foxtail (*Alopecurus pratensis*)	sections 1*a* and 5*a*, also 4*a* at high altitudes	high	early spring to late fall	early fall; 20 to 25 pounds	moist sandy loams to clay	very useful in pasture mixtures on wet soils, especially in 5*a*
Orchard grass (*Dactylis glomerata*)	Region 1, also sections 3*a*, 4*a* and 5*a* where moisture is plentiful	medium to high	early spring to fall	early fall or early spring; 20 to 25 pounds	any soil type except sand, if not too wet	inclined to grow in bunches unless seeded thickly

* By H. N. Vinall and C. R. Enlow, United States Department of Agriculture.

TABLE 27—*Continued*

INFORMATION REGARDING GRASSES FOR PERMANENT PASTURES *

Name	Climatic Adaptation	Degree of Palatability	Season of Grazing	Time and Rate of Seeding per Acre	Soil Adaptation	Remarks
Para grass (*Panicum purpurascens*)	section 2*b*	high	spring to fall	early spring, no seed available	wet soils	propagated by planting pieces of stem or sod
Perennial ryegrass (*Lolium perenne*)	southern half of Region 1 and in section 5*a*	high	early spring to late fall; winter grazing in Section 2*a* to limited extent	very early fall (or spring in North); 20 to 25 pounds	sandy loams to clays of medium to good fertility	used but little in pasture except in section 5*a*
Redtop (*Agrostis alba*)	Region 1, 2, and section 5*a*, also under irrigation and in mountain meadows, Sections 3*a* and 4*a*	medium	early spring to late fall	early fall best, early spring fair; 10 to 12 pounds	grows on majority of soil types; prefers moist soils	redtop is of most value on poorly drained soils too wet for other grasses
Reed canary grass (*Phalaris arundinacea*)	sections 1*a* and 5*a*, also 3*a* and 4*a* where moisture is plentiful	medium	spring to fall	very early spring; 8 to 12 pounds	loams to heavy clays	seed very expensive; very good for wet lands, will endure submergence
Rescue grass (*Bromus catharticus*)	Region 2 and where moisture is sufficient in sections 3*b* and 4*b*	medium	fall to spring (winter pasture)	early fall; 20 to 25 pounds	sandy loam to clay loam	an annual used in some localities for winter and spring grazing

Rhodes grass (*Chloris gayana*)	Section 2*b*; also southern parts of 3*b* and 4*b*	medium	spring to fall	spring; 10 to 12 pounds	loams to clays	found most useful in the dry sections of southern Texas where other grasses fail
Slender wheat grass (*Agropyron panciflorum*)	northern parts of Sections 3*a* and 4*a*	high	early spring to late fall	early spring; 15 pounds	practically any type, except sand	better for hay than pasture; inclined to be stemmy
Tall oat grass (*Arrhenatherum elatius*)	sections 1*b* and 5*a*	medium	early spring to late fall	early fall; 20 to 25 pounds	practically any type, except sand	better in hay mixtures than for pasture, stemmy, used most for pasture in section 5*a*
Timothy (*Phleum pratense*)	Region 1 and section 5*a*, also 3*a* where moisture is sufficient	high	early spring to late fall	early fall (or early spring); 12 to 15 pounds	practically any type, except sand	comes quickly and furnishes much pasturage at first, but is not permanent

* By H. N. Vinall and C. R. Enlow, United States Department of Agriculture.

this country during colonial times. According to the 1937 Yearbook of Agriculture (177), the name timothy was derived from Timothy Hansen, who obtained seed from New England or New York and introduced it into Maryland, and possibly into some of the other southern colonies, about 1720.

Timothy is grown primarily in the Corn Belt, the Dairy Belt, the eastern portions of the winter and spring wheat areas, and along the coast in the Pacific Northwest. The map in Fig. 103 indicates the chief areas in which timothy is important.

Since timothy is rather infrequently grown alone for hay, statistical reports of production usually combine clover and timothy. An average of 25,189,000 acres of clover and timothy were harvested during the period 1927 to 1936.

During the period 1927 to 1936, an average of 490,370 bushels of timothy seed was produced in the United States. Iowa, Missouri, and Illinois in the order named are the most important producers of timothy seed.

A recent bulletin of the Ohio Agricultural Experiment Station, devoted to timothy culture (42), indicates the reasons for the wide use of this grass. Its palatability, relatively low cost of seeding and harvesting, infrequent failure of new seedings, permanency of stand under favorable conditions, and high rank among the grasses in productivity are listed as the good qualities possessed by timothy.

From Ohio investigations it has been concluded that 3 to 4 pounds of seed per acre may be regarded as a satisfactory rate of seeding with winter grain in the fall. When timothy is seeded in the spring with oats, tests indicated that a 10-pound rate of seeding was satisfactory.

A significant result of the Ohio experiments is that timothy and red clover, seeded together, outyield either crop when seeded alone.

As a result of fertilizer tests with timothy at the Ohio Station, it was found, as an average of 5 years, that the percentage of protein in the hay grown on the unfertilized plots was 6.04 per cent. Applications of 50, 100, or 200 pounds of nitrate of soda per acre did not increase the percentage, but applications of 300 to 1600 pounds increased it 0.53 to 2.55 per cent.

Timothy should be cut in the early bloom stage if a combination of the greatest quantity and the best quality of hay is to be secured.

Regional Adaptations of Major Grasses and Legumes. The grasses and legumes of importance for pasture are also the most important for hay purposes and for soil conservation. The following classification,

according to adaptation of major grasses and legumes for permanent pasture, was prepared by Mr. H. N. Vinal and C. R. Enlow of the United States Department of Agriculture, Bureau of Plant Industry.

Grasses for the Northern States.[1] There are a great many northern grasses to choose from in planning pasture mixtures for the humid areas of the Northern States. The ones more commonly used are timothy, Kentucky bluegrass, redtop, orchard, perennial rye, tall meadow oat, meadow fescue, Canada blue, and brome grass. In the more arid regions, crested wheat grass, brome grass, and slender wheat grass are used with considerable success.

Perennial Ryegrass. This is a grass fairly common in section 5*a*, where it is quite well adapted. This grass gives good grazing and makes good hay, but is not sufficiently winter hardy to be used in the most northern states, and the abundance of short-lived plants that are present in a planting from commercial seed causes the stand to thin out in two or three years.

Tall Meadow Oat Grass. This grass is valued for the early grazing it affords in the spring. It is useful only in mixed seedings and is best adapted in sections 5*a* and 1*b*.

Meadow Fescue. This is a desirable pasture and hay plant in section 5*a*, the mountain meadows of section 4*a*, and in the western part of section 1*b*. In these sections it is a permanent grass, but seedings farther east in the Corn Belt are generally short-lived.

Reed Canary Grass. This is an excellent grass for wet lands, but does well also on upland soil. It is a northern grass and probably will be of most value in sections 1*a* and 5*a*. Reed canary grass is subject to becoming sod bound with age. Heavy discing or shallow plowing would probably cause renewed growth.

Canada Bluegrass. This is a grass which is particularly well adapted to the poorer soils of section 1*a*, where it makes a good addition to a pasture mixture. It makes a thin, wiry growth, but is readily grazed and appears to be very nutritious.

Brome Grass, or Smooth Brome. This is a very palatable grass which deserves a place especially in drier regions. It tends to become sod bound and forms such a close turf that legumes and other grasses are not able to grow with it in mixtures.

Kentucky Bluegrass. Of all the introduced grasses, this is the most important from a pasture standpoint, and because of its use on lawns is most widely distributed. In many sections of our Northern States it appears spontaneously in fields that are not cultivated for several

[1] Note map of regional adaptations, Fig. 103.

years. Taking advantage of this characteristic, the farmer may omit Kentucky bluegrass seed from pasture mixtures in natural bluegrass areas. It will gradually invade the field and finally will become the dominant grass if soil conditions are favorable for its growth.

Meadow Foxtail. This grass is not so well known as the other grasses recommended for pasture seeding. It has been found most useful on wet soils in section 5*a*, but is also much at home in the high mountain meadows of section 4*a*. A more extensive use of meadow foxtail on wet soils in Region 1 is justified. (See Fig. 103.)

Orchard Grass. This grass is not so palatable as several of the well-known grasses, but contributes very materially to pasturage because it endures shade better than most grasses and is more productive on soils of low or moderate fertility. It begins growth early in the spring and the excess growth in the fall provides considerable winter grazing.

Redtop. Like orchard grass, redtop is not relished especially by livestock, but is generally included in the pasture mixture because of its ability to grow on poorly drained, acid soils.

Slender Wheat Grass. This grass is perhaps better suited for use as a hay plant than for pasture. However, until the introduction of crested wheat grass, slender wheat grass and brome grass were the only grasses available which could be grown successfully under the unfavorable climatic conditions prevailing in the northern Great Plains and in the adjacent areas in Canada. For grazing, mixtures of slender wheat grass and sweet clover are usually preferable to pure stands of either.

Colonial (Rhode Island) Bent and Creeping Bent. These grasses are found in many pastures in the New England States, and a form of creeping bent, known as seaside bent, is abundant on moist soils in Region 5. These are all more valuable in lawns than in pastures.

Red Fescue (Festuca rubra). This is a fine-leaved, persistent, turf-forming grass which is of little value in pasture mixtures because cattle do not find it palatable. It grows best in the shade and is valuable in lawn mixtures.

Sheep's Fescue (Festuca ovina). A near relative of red fescue, which is a small bunch grass, sheep's fescue is very drought-resistant and of some value on sheep ranges.

Crested Wheat Grass. An importation from Russia which will endure extremes of drought and cold, crested wheat grass shows much promise for regrassing land in the northern Great Plains. It was put in cultivation during the first World War.

Grasses for the Southern States. The southern grasses which contribute most to the pastures are the Bermuda, carpet, and dallis grasses. Those less commonly found in pastures are the Johnson, Centipede, Rhodes, Napier, Rescue, and Vasey grasses. Para, Bahia, Guinea, and Molasses grasses are hardy only in the subtropical belt along the Gulf Coast, indicated on the map as section 2*b*. They can also be grown on irrigated lands along the Mexican border, in sections 3*b* and 4*b*.

Carpet Grass. Carpet grass is a turf grass which is persistent and aggressive on moist sandy soils and often appears spontaneously in Region 2, where the land has been cleared and grazed heavily while protected from fires. It endures close grazing very well, but is not very productive, only fairly nutritious, and makes such a close turf that it is very difficult to keep legumes in it.

Bermuda Grass. This grass has spread naturally on loam, clay, and silt soils over most of the Cotton Belt and even a little north of the 60-degree isotherm. It is late starting in the spring and ceases growth at the first light frost in the fall. In the irrigated sections of 3*b* and 4*b*, Bermuda grass produces viable seed and spreads out into the cultivated fields, where it is a nuisance.

Dallis Grass. Dallis grass is a long-lived perennial grass which, though less abundant than carpet and Bermuda, is becoming increasingly important as a grazing plant in Region 2. It is a bunch grass, and the turf is more open than that of the two grasses first named. The growth of basal leaves is luxuriant and dallis grass pastures are both productive and nutritious. The chief drawback is the difficulty of obtaining a good stand. A fungus (*Claviceps paspali*) in the seed heads, which, if eaten in any quantity by cattle causes a disease known as ergotism, may easily be controlled by preventing the production of seed heads through the heavy grazing or mowing of the pasture.

Johnson Grass. Although it is best known as a pest in cultivated fields, Johnson grass is also found in pure stands where it is utilized as a hay crop and to a lesser extent as pasture. When grazed closely and continuously, it gradually becomes unproductive and is not very desirable in pastures.

Centipede Grass. A rather recent introduction from China, Centipede is an aggressive, stoloniferous grass, much like carpet grass in its tendency to form a very compact turf which gradually excludes other grasses and legumes, leaving pure stands of Centipede grass. Such Centipede grass pastures are low in productivity, and their nutritive qualities are questionable. Centipede grass will grow on most

soil types, but appears to best advantage on sandy soils of the Norfolk series.

Rhodes Grass. This is a grass that has been tested in most parts of Region 2 and sections 3*b* and 4*b*, but has achieved importance only on some of the large ranches in southern Texas, where a drought-resistant plant is required. It will grow on moderately alkali soils but is less palatable under such conditions. Seed is expensive and difficult to obtain in quantity.

Vasey Grass. This resembles dallis grass very much but has fewer basal leaves and is less valuable for pastures. It comes in spontaneously on the rice and sugar-cane lands of southern Louisiana.

Rescue or Arctic Grass. This is a winter annual that often reseeds naturally in southern Texas. It appears usually at the end of the dry summer season and provides grazing after Bermuda grass has become dormant.

Para Grass. Para grass is characterized by its long, coarse, trailing stems and very rapid growth under favorable conditions. It is very sensitive to low temperatures and is of most value on wet lands. No seed is available; therefore it must be propagated vegetatively.

Bahia Grass. This grass is not grown to any extent except in Florida. It is of most value on poor sandy soils. Seed is expensive and usually of low germination.

Guinea Grass (Panicum maximum). This is a large, coarse, bunch grass that is very drought-resistant and one of the most dependable pasture grasses of the West Indies. In the United States it never has become popular, but should be valuable in southern Texas where Rhodes grass has succeeded.

Molasses Grass (Melinis minutriflora). Molasses grass is one of the most productive grasses in Brazil and Colombia, South America, where it is known as Gordura. It has fine stems and makes a very dense, leafy growth about 2 feet deep over the ground. The leaves and stems exude a sticky, sweetish fluid which gives the grass an odor. Cattle dislike the grass at first, but later appear to relish it and thrive on it to a remarkable degree. It can be grown only in practically frost-free localities, such as the southern half of Florida.

Natal Grass (Tricholaena rosea). Natal grass was introduced from South Africa, but has become naturalized in southern Florida and has spread to citrus groves and uncultivated land, including the roadsides. Natal grass appears well adapted to the climate and the sandy soil of this part of Florida, but it is not relished by livestock and contributes little to the pasturage resources of the United States.

CHAPTER XXII

ALFALFA AND SWEET CLOVER

ALFALFA

The production of alfalfa for hay and pasture occurs over a wide range of conditions in the United States. The following information is presented with a view to outlining the facts pertaining to production and practices as they are found in the various regions.

Climatic and Soil Factors in Alfalfa Production. Under western conditions, alfalfa is well adapted to regions rather deficient in surface moisture because of its deep and extensive root system. It requires, however, a moderately moist soil for seedling growth. Excellent underdrainage is essential. Alfalfa does poorly on soils having impermeable subsoils or shallow soils over rock. Alfalfa does well under irrigation.

Alfalfa is very sensitive to soil acidity. It does best on soils that are neutral. Lime is usually necessary if soil that has a *p*H below 6.5 is to be used for production. On acid soils it is best to apply the lime the season before alfalfa is to be planted.

Alfalfa is rather tolerant of alkali conditions. Most soils developed under conditions of low rainfall are chemically and physically favorable to alfalfa except those that are strongly alkaline, salty, or excessively sandy.

Alfalfa in Rotation. While alfalfa is not usually considered as a rotation crop because the stands of this crop under good conditions will live for a number of years, yet alfalfa is being used successfully in relatively short rotations. The Kentucky Station (45) reports that rotations such as corn, wheat, and two years of alfalfa are satisfactorily used in that state. At the Ohio Station (188), a thirteen-year average yield, in a rotation, of corn was 69.1 bushels; wheat, 36.9 bushels; and clover hay, 3544 pounds. These results may be compared with yields, for the same period, when grown in rotation, of corn, 75.9 bushels; wheat, 38.9 bushels; and alfalfa hay, 4649 pounds.

The West Virginia Station (48) suggests crop rotations as indicated in Table 28.

TABLE 28

SUGGESTED CROP ROTATIONS, INCLUDING ALFALFA, AND FERTILIZER TREATMENTS
(West Virginia Agricultural Extension Service)

Year	Crop	Cover Crop	Soil Treatment
1	corn	wheat or barley	6 tons manure and 200–300 lb. 20% superphosphate, or 400 lb. of 4–12–4 fertilizer per acre *
2	wheat or barley	alfalfa (seeded in spring on grain)	Lime according to lime requirement test and 500–600 lb. 2–14–4 fertilizer per acre
3	alfalfa		
4	alfalfa		
5	alfalfa		
1	corn	rye and vetch	6 tons manure and 200–300 lb. 20% superphosphate, or 400 lb. of 4–12–4 fertilizer per acre *
2	soybeans (cut for hay last week in July)	alfalfa (seeded by August 15)	Lime according to lime requirement test and 250 lb. 0–14–6 fertilizer on soybeans and 400 lb. 2–14–4 fertilizer per acre for alfalfa †
3	alfalfa		
4	alfalfa		
5	alfalfa		
1	corn	rye and vetch	6 tons manure and 200–300 lb. 20% superphosphate, or 400 lb. of 4–12–4 fertilizer per acre *
2	one-half seeding of oats or full seeding of spring barley	alfalfa (seeded with the grain)	Lime according to lime requirement test and 500–600 lb. 2–14–4 fertilizer
3	alfalfa		
4	alfalfa		
5	alfalfa		
1	early potatoes	alfalfa (seeded by August 15)	1500 lb. 4–10–6 fertilizer broadcast per acre for potatoes, and lime according to test after potatoes are harvested
2	alfalfa		
3	alfalfa		
4	alfalfa		

* If applied in the hill use half the amount.
† If manure is applied to previous crop of corn, substitute an 0–14–6 fertilizer.

For further information, see the section of this chapter pertaining to alfalfa in mixtures.

Alfalfa Fertility Requirements and Practices. In many sections of the West, adapted to alfalfa production, there appears to be little

need for fertilization. Under certain western conditions, however, alfalfa profits by particular treatments, and in the East, alfalfa pro-

FIG. 104. The top picture illustrates alfalfa growing on limed soil in the central bluegrass region of Kentucky. The bottom picture shows alfalfa growing on unlimed soil of the same type. (*Kentucky Agricultural Extension Service.*)

duction depends upon meeting fertility requirements in addition to liming.

From the results of some Colorado experiments (133), it seems that little is to be gained from applying either manure or fertilizer to the highly productive soils in northeastern Colorado. On soils known to be deficient in plant food, considerable increases in yield have been obtained from the application of treble superphosphate or manure.

The Oregon Station (142) reports that alfalfa yields are increased by the use of land plaster or sulphur. One hundred and twenty-five pounds per acre of land plaster, applied early in March, produced the largest increases in forage. In experiments with sulphur, this element, applied at the rate of 75 pounds per acre, gave the largest hay yields over a period of six years. It was found that fertilizing alfalfa with manure, lime, or any fertilizer containing sulphur lengthened the life of the stands and improved the quality and yield of the forage.

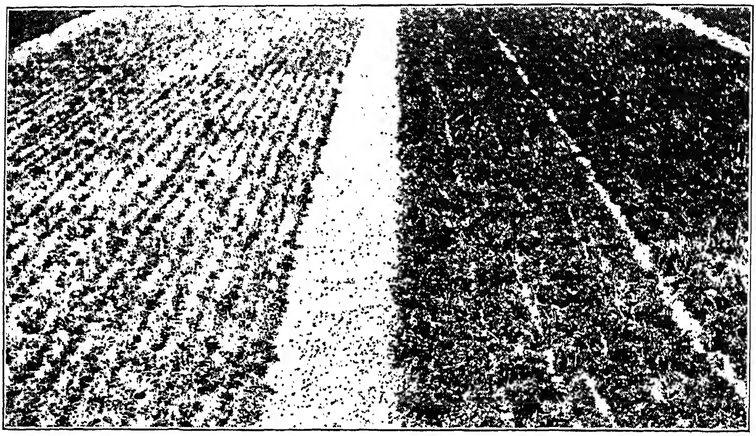


FIG. 105. After four seasons of growth, the hardy strain of alfalfa (right) is much more vigorous than the less hardy strain (left). (*Colorado Agricultural Experiment Station.*)

The West Virginia Station (48) recommendations for fertilizing crop rotations including alfalfa are presented in Table 28.

The North Carolina Station (78) suggests either a liberal application of manure to the previous crop in a rotation including alfalfa, or that a good growth of a leguminous crop be turned under a year before the alfalfa is planted. In addition, about 600 pounds per acre of a 2–10–4 fertilizer should be applied broadcast before planting.

This may be replaced by 600 pounds of a 0–14–4 fertilizer if the soils are particularly fertile and have had a heavy application of manure or if a heavy growth of legumes has been turned under. A top dressing in early spring of 400 pounds of a 2–10–4 fertilizer or a liberal application of well-rotted stable manure is suggested.

Observations and investigations in Ohio (188) indicate that the fertilization of alfalfa at seeding time may be suggested as follows: on light-colored sandy soils, 300 to 400 pounds of 2–12–6; on poorer,

light-colored silt loams and clays, 300 to 400 pounds of 2–14–4; on dark-colored silt loams and clays and on the better light-colored soils, 250 to 350 pounds of 0–14–6; on peats and mucks, 250 to 350 pounds of 0–12–12.

Alfalfa Seed. While it is very important to use plump, clean, high-germinating alfalfa seed for seeding purposes, yet the most important consideration is that of adaptation. Seed of type or strains adapted to the conditions under which the alfalfa is to be grown is essential. The buyer of seed must depend upon the integrity of the growers and seedsmen from whom the seed is secured, because there is no way of distinguishing differences in varieties and strains by an inspection of the seed. According to the seed laws of the United States, imported alfalfa seed must have a certain percentage of seed, colored or stained as prescribed by regulations.

For alfalfa seed from any foreign country, this means that 5 per cent of the seed in each container is to be colored green, with the following exceptions:

Seed from Turkistan, 10 per cent purple-red.
Seed from Africa, 10 per cent red.
Seed from South America, 10 per cent orange-red.
Seed from Canada, 1 per cent iridescent violet.
Seed from unestablished or mixed origin, 10 per cent red.

The adaptation of alfalfa varieties is illustrated in Fig. 106.

Alfalfa Seeding. In Colorado (133) where most alfalfa is grown under irrigation, it is important to level the seed bed to facilitate the use of irrigation water. A smooth, firmly packed, moist, weed-free seed bed is necessary. Spring or early fall plantings may be used. Eight to ten pounds of seed may be drilled $\frac{1}{2}$ to 1 inch deep, or broadcasted. After seeding, the land should be harrowed or packed to cover the seed and put it in contact with firm, moist soil. Under Colorado conditions, good results were obtained when alfalfa was sown with a companion crop of flax or peas. Barley as a companion crop tended to reduce alfalfa yields to some extent.

Under western Oregon (142) conditions, 12 to 15 pounds of seed per acre, seeded in late April, May, or early June, without a companion crop, seems to bring best results.

Recommendations by the North Carolina Station (78) are that the seed bed for alfalfa should be prepared by fairly deep plowing and thorough pulverization, followed by several weeks of settling with

frequent harrowings of the surface. It has been found that fall seedings are usually more satisfactory than spring seedings in the Piedmont, Coastal Plain, and lower elevations in the mountains. Seeding dates range from August 1 to September 30. Spring seedings during April are suited to elevations of 2500 feet and above. At least 25 and

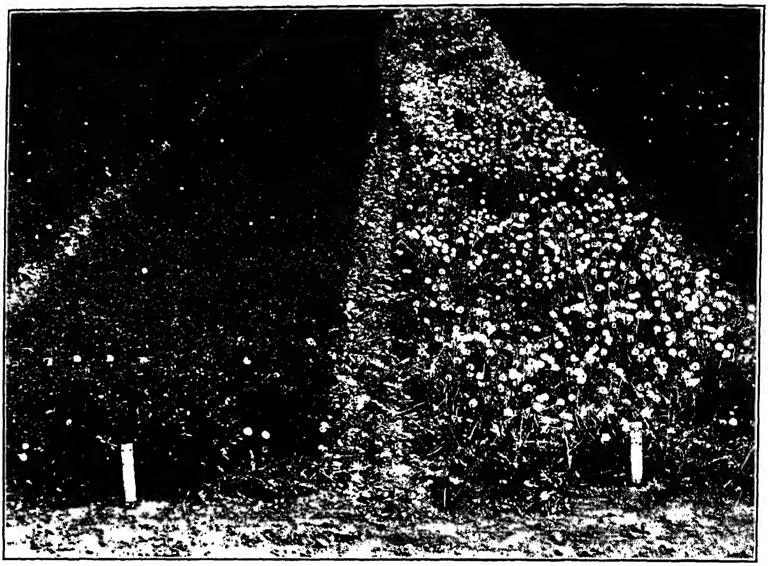


FIG. 106. Michigan conditions require hardy varieties of alfalfa. The Hardigan alfalfa (left) may be compared with the Hairy Peruvian (right). The flowers in the Hairy Peruvian plot are dandelions. (*Michigan Agricultural Experiment Station.*)

preferably 30 pounds of seed per acre should be planted in these regions to secure best results.

The following material, adapted from a report of the Ohio Station (188), summarizes some of the findings pertaining to seeding alfalfa.

a. Experiments combined with farm and station experience substantiate the recommendation of a standard rate of seeding of 10 to 12 pounds per acre.

b. When alfalfa is seeded in the spring it seems that the earlier the alfalfa is sown the better, provided the seedlings are not killed by freezing. The period, March 20 to April 1, seems preferable at Columbus, Ohio. When seeding in wheat, dividing the seed (sowing half broadcast about March 10 to 15, or about the end of the

period for "honey-combed" ground seedings, and the remainder either drilled or broadcasted about April 1, or two to three weeks later) has given excellent results in the Columbus experiments.

c. Three reasons are given for using a companion crop: (1) to obtain some return from the land in the seeding year; (2) to prevent weed competition; and (3) to prevent erosion. A companion crop is always injurious; but, in many instances, if a companion crop is not sown, a companion crop of weeds will spring up which will do the alfalfa more injury and have less value than the sown companion crop.

d. Early oats or barley are the best companion crops for alfalfa followed by winter wheat or late oats. As a means of obtaining a stand of alfalfa, sowing in soybeans is too hazardous to be recommended. Sowing alfalfa in corn after the last cultivation is not to be recommended except in the case of unusually favorable conditions on soils especially well adapted to alfalfa.

e. If seedings can be made in late March or early April, good stands of alfalfa may be secured by seeding alone in the spring.

f. Since summer seedings are always under the handicap that less time is available for root growth and root storage, the earlier the alfalfa can be sown after July 1 the better, provided moisture conditions are favorable. To be successful, summer seeding must be on a well-prepared seed bed, that is, one which is free of weeds, level, reasonably fine on top, and well connected with the subsoil, and one which contains abundant stored moisture.

g. When seeding with spring grain in loose soil, it is best to have the seed fall behind the grain discs so that the seed is covered only by the covering chains and the settling of the soil. Broadcasting alfalfa seed immediately after drilling grain is also satisfactory. When seeding on winter wheat on light-colored soils which tend to settle firmly during the winter, drilling is desirable and the seed should go through the grain tubes. Harrowing or cultipacking may be necessary to cover the seed sufficiently. Cultipacking seems particularly beneficial if the seeding is followed by a period of little rain.

h. The cultipacker is especially desirable for summer seedings. At Columbus, Ohio, the cultipacker has been effectively used in summer seedings of alfalfa (also for clovers and grasses, including fairways on golf courses). As soon as the ground is dry enough to work after a rain which penetrates the entire plowed layer, it is harrowed and cultipacked (at one operation, if a tractor is used), and the seed sown broadcast, then covered either by cultipacking

or by harrowing lightly crosswise of the cultipacking. The seed falls in the furrows of firm soil left by the cultipacker, is covered to a uniform shallow depth, and germinates in rows as though drilled. This is probably one of the most satisfactory methods that has been found for making summer seedings. In many instances, this method may also be satisfactorily used for spring seedings.

Inoculation. If the land to be seeded to alfalfa has not grown good crops of alfalfa or sweet clover for a number of years, it is essential to inoculate the seed with a commercial inoculant or to mix seed with soil known to contain suitable organisms.

The importance of inoculation is presented in Table 29.

TABLE 29 *

EFFECT OF NODULE BACTERIA ON NITROGEN CONTENT AND YIELD OF ALFALFA

Location	Nitrogen (Pounds per Acre)			Yield (Pounds per Acre)		
	With bacteria	Without bacteria	Gain	With bacteria	Without bacteria	Gain
Wisconsin	86.7	46.2	40.5	2866.2	1714.8	1151.4
Illinois	62.0	21.8	40.2	2300.0	1180.0	1120.0
Minnesota				3022.0	1293.0	1729.0
England	74.0	42.6	31.4	2654.4	1624.0	1030.4

* Circular Bulletin 154, Agricultural Experiment Station, Michigan State College.

Clipping New Alfalfa Seedings. If spring seedings develop a large amount of growth, it may be satisfactory to clip for hay in the early fall, providing enough time remains for sufficient growth to take place before winter. In the Corn Belt such clipping should occur before September 1.

It may also be necessary to clip alfalfa seedings if weeds threaten the stand or if companion-crop stubble needs to be removed. If there is a large amount, the clippings should be removed; otherwise, their presence will cause no particular trouble.

Cutting Alfalfa for Hay. Numerous factors must be considered when cutting alfalfa for hay. If cut early, the quality of the hay is high and the protein content is high. Investigations, however, have demonstrated that early cutting reduces the vigor of the stand. Late cutting reduces the quality of the hay but preserves the vigor of the

stand. The number of cuttings per season varies from two to five. It is essential to make the last cutting in the fall early enough to permit the formation of adequate root reserves to carry through winter and start the spring growth.

In the Western States, the time of cutting is largely determined by the condition of bloom. In the Eastern States there is some dif-

FIG. 107. Roots of alfalfa plants which have been heaved from the soil by frost action. Late fall cutting contributes to such injury. (*J. C. Allen and Son, West Lafayette, Indiana.*)

ficulty in following recommendations based on blooming because of variations induced by more humid weather conditions.

Extensive investigations at the Ohio Station (188) form the basis for recommending calendar dates as a guide for cutting alfalfa. The dates which have been established in that state are presented in Table 30. As an example, the first cutting for the middle third of the state is made June 7 to 14, to obtain the maximum protein per acre. The last cutting is made September 3 to 10, to allow ample opportunity for growth to replenish the reserves in the roots. The second cutting divides the time between the first and third cuttings and is regulated by the attacks of leafhoppers and by the weather.

With good alfalfa the Michigan Station (5) suggests to start cutting when in tenth bloom or earlier and to try to complete the harvest

TABLE 30 *

CUT ALFALFA BY THIS CALENDAR IN OHIO

Sections of Ohio	First Cutting	Second Cutting	Third Cutting	Fourth Cutting
Southern third—1st and 2nd "bottoms"	May 28 to June 4	June 28 to July 5	Aug. 3 to 10	Sept. 8 to 15
Southern third—uplands	June 3 to 10	July 20 to 27	Sept. 3 to 15	
Middle third	June 7 to 14	July 20 to 27	Sept. 3 to 10	
Northwest	June 7 to 14	July 20 to 27	Sept. 1 to 7	
Northeast	June 9 to 16	July 20 to 27	Sept. 1 to 7	

* Ohio Agricultural Experiment Station.

before the time of full bloom. Further recommendations are that in mowing the second time it is best to begin where the first cutting was mowed last, and that it is important to avoid cutting or heavy grazing in mid-September.

The Colorado Station (133) states that alfalfa should be cut for hay when in one-tenth to one-fourth bloom. The North Carolina Station (78) makes the same recommendation.

Curing and Storing Alfalfa Hay. The problems in curing alfalfa hay are particularly acute in the relatively humid regions of the Corn Belt. The first cuttings of alfalfa are often made at a time when frequent rains may be expected. The curing of alfalfa hay under such conditions is presented in part by Table 31, selected from a Michigan publication (5).

Very high quality hay can usually be made by raking a few hours after cutting and curing the hay in small cocks. This system requires much hand labor and is a slow method compared to the curing of alfalfa hay in the windrow. The windrow method is well adapted to the use of machinery. It consists in raking with a side-delivery rake immediately after or within a few hours of cutting. After the hay is sufficiently cured (moisture content reduced to about 25 to 30 per cent), the windrows are picked up with a hay loader.

The objects in curing alfalfa hay are to reduce the water content of both stems and leaves to a safe level for storage and to prevent rains and weathering from reducing the quality of the hay, particularly the protein content. It is essential to carry on the haying operations in a manner to prevent the loss of leaves.

Investigations at the Iowa Experiment Station (62), in connection with the making of alfalfa hay, revealed a number of facts useful in establishing the principles of making such hay. It was found that the turning of average-sized windrows in good curing weather saved

little time in curing and that the quality of the hay was decreased to a slight extent. It was found advisable to turn large windrows or windrows wet with rain.

TABLE 31

INFLUENCE OF CURING METHODS ON THE RATE OF DRYING AND PROTEIN CONTENT OF ALFALFA HAY

(Average for seven cuttings, 1932–1933–1934, East Lansing, Michigan)

Curing Method	Hours to 25 Per Cent Moisture	Percentage Crude Protein in Cured Hay
Raked 4 hours after cutting, cured in cocks	75.14	16.68
Raked immediately after cutting, cured in windrows	51.57	15.64
Raked 4 hours after cutting, cured in windrows	50.00	15.71
Raked 24 hours after cutting, curing completed in windrows	48.71	15.00
Cured in swath	46.57	13.74

The use of a tedder or the excessive use of the rake in turning windrows reduced the quality of the hay through the loss of leaves.

It was found that hay with less than 30 per cent of moisture could ordinarily be considered safe from heating, while hay with less than 27 per cent moisture could be expected to retain its green color. Hay generally heats immediately after being put into the mow, cools off to a certain extent, and reaches a second high point in heating 8 to 10 days after being placed in the mow, and then cools off gradually.

According to Iowa investigations in eight trials of salting hay, a distinctly beneficial result was obtained once, a slightly beneficial outcome once, and no particular benefit in the balance of the trials.

Investigations carried on at the Tennessee Station (183) indicate the feasibility of curing hay within barns by forcing unheated air through the hay in the mow, by means of motor-driven blowers. Air ducts are installed in the mows, and hay stored over these ducts can be ventilated in such a manner as to prevent excessive heating and at the same time promote satisfactory curing. The method appears to be relatively inexpensive as compared to other artificial methods of drying hay.

Alfalfa Diseases and Insects. Leaf spot, caused by the fungus *Pseudopeziza medicciginis*, seems to be the most common foliage disease of alfalfa. Leaves infected with this disease turn yellow and

drop from the plants. The infection lives from year to year on the infected leaves that have fallen to the ground. Thus the early cutting of diseased stands and the removal of the crop helps to reduce the amount of infection in succeeding crops.

Bacterial wilt, caused by the organism *Aplanobacter insidiosum*, appears to be one of the serious diseases of alfalfa. According to the 1937 Yearbook of Agriculture (177), it is the greatest threat to

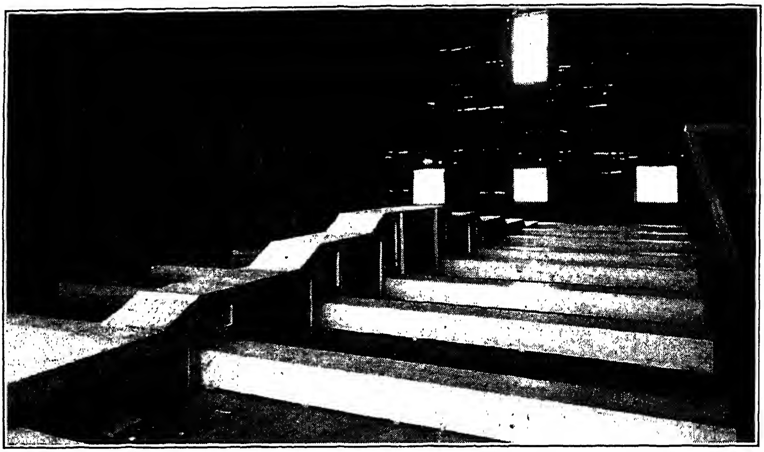


FIG. 108. Air ducts have been placed in this barn and the hay is cured by forcing unheated air through the hay in the mow by means of motor-driven blowers. (*Tennessee Agricultural Experiment Station.*)

alfalfa growing in the United States. It kills stands of susceptible alfalfa in two to four years.

Badly infected plants are dwarfed and stunted and have leaves of a pale-green color. Diseased plants tend to develop an abnormally large number of stems. When the tap root of a diseased plant is cut crosswise, there is a yellowing of the outer portion of the woody cylinder to be noted. The outside of the roots may have brown cankerlike lesions.

A report of the Michigan Station (5) indicates that control measures have not been perfected. Alfalfa breeders are in search of strains resistant to this disease.

Alfalfa is troubled also by yellow leaf blotch, various root rots, and with stem rot. Grasshoppers, cutworms, armyworms, and the alfalfa weevil cause considerable damage to stands of alfalfa.

Investigations have revealed that a seemingly mysterious yellowing of alfalfa stands appears to be the result of infestations of leaf-

hoppers. These small insects suck the sap from the growing plants. The attacks of these insects upon new stands cause the greatest injury. The first cuttings of established stands of alfalfa are not harmed to any great extent, but the succeeding cuttings may be injured rather extensively.

FIG. 109. The leaf spot disease of alfalfa causes the leaves to turn yellow and to fall from the plant. (*Michigan Agricultural Experiment Station.*)

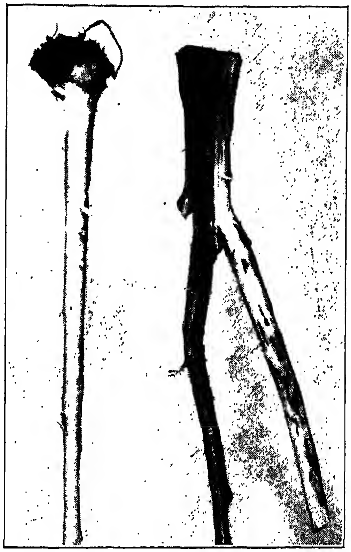


FIG. 110. The alfalfa root (right) shows the lesions caused by bacterial wilt. The root to the left is normal. (*Michigan Agricultural Experiment Station.*)

The injury from leafhoppers may be avoided somewhat by making certain variations in the time of cutting; adjustments have to be made in accordance with local conditions.

Alfalfa in Mixtures. It has been found advantageous in many areas to grow alfalfa in mixtures with various grass crops or other legumes. At the Michigan Station (126) a mixture of alfalfa and smooth brome grass has been found particularly suitable for pasture purposes.

Investigations at the Ohio Station (188) reveal that orchard grass and alfalfa make a good combination. The first growth of the grass in the season matures with the alfalfa and, since orchard grass de-

velops a strong aftermath, much of the grass is found in succeeding cuttings. The cost of securing orchard-grass seed is somewhat of an objection to its general usage.

Timothy is often used to advantage with alfalfa. If alfalfa fails, the timothy tends to make a stand. The Ohio Station finds that the timothy decreases in vigorous stands of alfalfa.

FIG. 111. At the Michigan Station a mixture of alfalfa and smooth brome grass has been found particularly suitable for pasture purposes. (*Michigan Agricultural Experiment Station.*)

Alfalfa-oat grass mixtures have been tried by the Ohio Station, but it is reported that the lack of palatability of the oat grass and the very high price and poor quality of the seed make the mixture impractical.

Pasturing Alfalfa. Alfalfa has been found well suited for pasture purposes and is being used for pasture in many places. If alfalfa is not grazed too closely and if sufficient fall growth is permitted to carry the plants over winter, the stands may be expected to persist about as well as when the crop is harvested for hay purposes.

Livestock may bloat on alfalfa pasture if certain precautions are not observed. Extremely hungry animals should be given a full feed before being turned into an alfalfa pasture. It is well not to graze the

first new growth. After starting animals on alfalfa pasture, the stock should be kept continuously on the pasture. Water and salt should be easily available to the stock.

Alfalfa Seed Production. When alfalfa is grown in regions of low humidity and in the drier seasons in such states as Michigan, Minnesota, and Wisconsin, a harvest of alfalfa seed may be secured. When six or seven out of ten blooms show a swelling at the base,

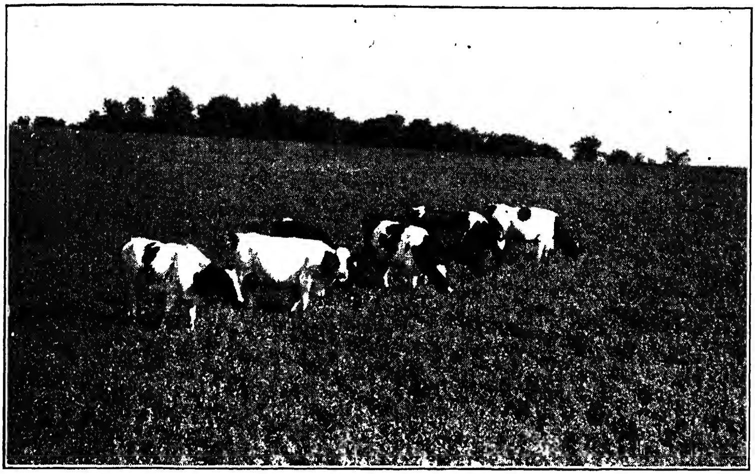


FIG. 112. Alfalfa may be used for pasture when measures are taken to maintain the stand and to prevent the loss of animals from bloating. (*J. C. Allen and Son, West Lafayette, Indiana.*)

indicating seed formation, a seed crop worthy of harvest is developing.

The Montana Extension Service (99) states that if the alfalfa bloom remains fresh without any sign of withered blossoms that hang on the stem, the alfalfa should be cut for hay. Withered blossoms, pulled lightly between the fingers, will give an indication of whether the blossoms will stick on the stems and form pods. Withered blossoms which slip off easily, leaving bare stems, are an indication that little seed will be formed.

Alfalfa for seed should be harvested when 50 to 75 per cent of the pods have turned brown. Ordinarily it is best to cut the crop, cure it in small cocks and then stack. In this process special attention must be given to handling the crop carefully and under conditions that will prevent the loss of the seed.

When thoroughly dry, the alfalfa may be threshed with a grain separator, equipped with alfalfa screens. When available, a clover huller is the best implement to use.

Botanical Classification of Alfalfa. Common alfalfa, *Medicago sativa,* includes the ordinary purple-flowered types of alfalfa, of which there are numerous strains. *M. falcata* is a hardy yellow-flowered alfalfa of no particular commercial importance. Hybrids of *M. sativa* and *M. falcata,* however, have given rise to a so-called variegated group of alfalfas that are economically very important because of their hardiness.

The following classification is adapted from a publication of the United States Department of Agriculture (163).

A. Common-Alfalfa Group

The stock from which most of the common alfalfa of our Western States has been produced was brought from Spain to Chile and then introduced into California about 1850. The domestic strains of common alfalfa produced in the United States are usually designated by the name of the state in which the seed was grown such as Kansas or Montana Common. Other descriptive names may be used such as "dry land" or "irrigated." Most of the seed coming from Argentina belongs to the common alfalfa group as does also South African alfalfa and Provence alfalfa from southeastern France.

B. Turkistan Group

Turkistan alfalfa was first introduced into the United States through the efforts of the United States Department of Agriculture in 1898. The superior cold resistance of the early importations resulted in its use in the cold dry regions of the northern Great Plains. In later years much of the imported seed was planted in eastern areas of the United States with rather poor results which brought about a reduction of its use. Recently, interest in this alfalfa has been renewed because of its resistance to bacterial wilt as well as its resistance to cold, although strains vary to a large extent in these characteristics.

Hardistan is the name given by the Nebraska Agricultural Experiment Station to a promising strain of Turkistan alfalfa grown in that state for several years. Kaw is the name given by the Kansas Agricultural Experiment Station to a promising strain of Turkistan alfalfa grown in that state.

C. Variegated Group

The variegated alfalfas have resulted from natural crosses between the purple-flowered and the yellow-flowered species.

Grimm alfalfa is the most important member of the variegated group in the United States. It was introduced from Germany into Carver County, Minnesota, in 1857, by Wendelin Grimm, and eventually attracted considerable attention on account of its cold resistance. [For a rather complete ac-

count of the story of Grimm alfalfa refer to the 1937 Yearbook of Agriculture (177).]

Cossack alfalfa was introduced into this country from Russia through the efforts of the United States Department of Agriculture in the year 1907. It is adapted for growing under practically the same conditions as Grimm alfalfa.

Canadian variegated or Ontario variegated is the name given to an alfalfa of hybrid origin grown in eastern Canada for many years.

Ladak alfalfa came from a small quantity of seed obtained in 1910 from Ladak, India, by the United States Department of Agriculture. This alfalfa seems most promising for the cold dry conditions found in the northern Great Plains.

Baltic alfalfa is similar to Grimm and received its name in 1906, from the fact that it had been grown for about ten years near Baltic, South Dakota.

Hardigan alfalfa is a selection from Baltic made at the Michigan Agricultural College. It is noted for its high seed production and desirable forage characteristics.

D. Nonhardy Alfalfas

Peruvian alfalfa was first introduced into the United States through the efforts of the United States Department of Agriculture in 1899. Two types, the "smooth Peruvian" and the "hairy Peruvian" were grown for a period of years. The hairy Peruvian is the only one which receives much attention at the present time. As compared to common alfalfas, Peruvian is more upright in growth and less branched. Lack of hardiness confines Peruvian alfalfa to the southern and northwestern portions of the United States.

Arabian alfalfa was introduced into the United States in 1902 but it has not achieved commercial importance.

E. Yellow-Flowered Group

The yellow-flowered alfalfas are of no commercial importance but because of their cold resistance they are valuable for hybridizing purposes in seeking hardier strains.

Botanical Characteristics of Alfalfa. Alfalfa is a long-lived perennial under conditions which favor its growth. The young plant usually has a tap root but soon develops a number of vigorous roots extending many feet into the ground. The stems of the alfalfas commonly grown are ascending or erect. Crowns are formed at or near the ground level from which the stems of the plant arise.

The flowers of common alfalfa are purple, whereas the variegated alfalfas have flowers varying from purple to yellow. Alfalfa may be either self- or cross-pollinated. The flowers have an arrangement or mechanism involving "tripping," for the explosive dispersal of pollen. Seeds are produced in curled pods containing one to eight seeds per

pod. The heaviest yields of seed occur in the drier sections of the Great Plains States.

An important characteristic of alfalfa is its ability to send up new shoots from the crowns of the plants. This provides the opportunity for a number of cuttings to be secured during a growing season.

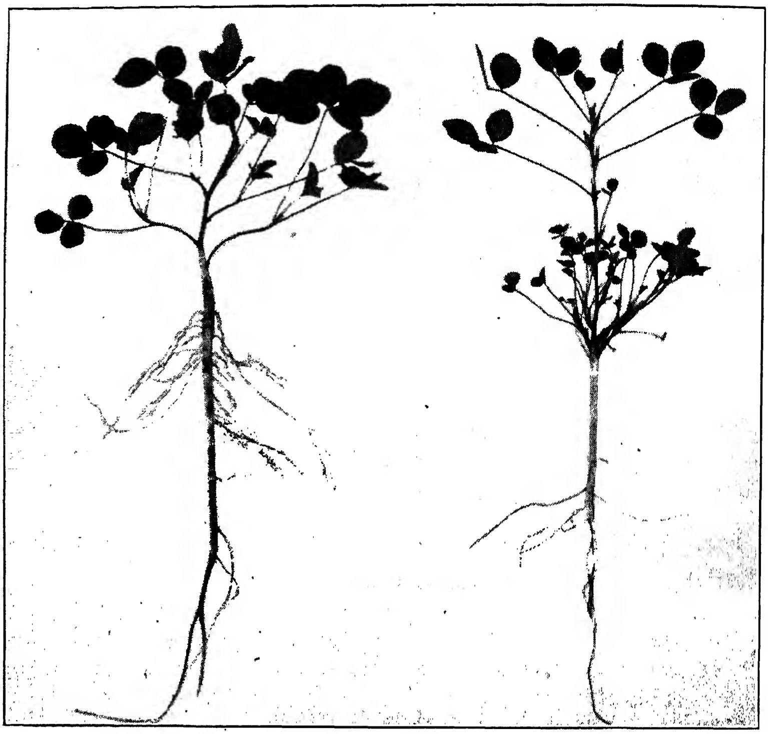


FIG. 113. The plant to the right is a young alfalfa plant showing the early development of the crown. On the left is a young plant of sweet-clover. (*Illinois Agricultural Experiment Station.*)

Origin and History of Alfalfa. As stated in the 1937 Yearbook of Agriculture (177), it appears that the original home of alfalfa was in southwestern Asia. The earliest records alluding to alfalfa were discovered in Babylonian text material written in 700 B.C. It is stated by the early Roman writers, Pliny and Strabo, that alfalfa was introduced into Greece by the invasions of the Medes and Persians in 490 B.C.

The Spanish explorers, Cortez and Pizarro, at the beginning of the sixteenth century, introduced alfalfa into what is now Peru and Chile.

From these areas alfalfa was introduced into California, New Mexico, and Arizona.

Alfalfa, under the name of Lucerne, was introduced into the Atlantic Seaboard Colonies by the English, French, and Germans. George Washington and Thomas Jefferson grew alfalfa on their plantations.

Further details of the early history of alfalfa may be found in the 1937 Yearbook of Agriculture (177).

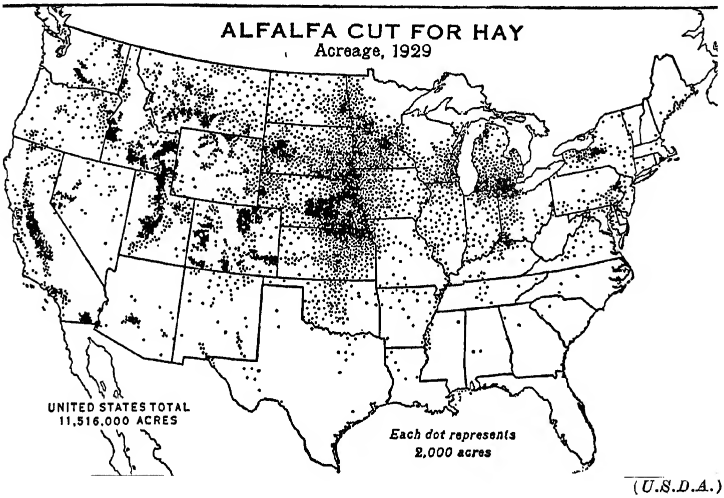


Fig. 114.

Composition of Alfalfa. Information pertaining to the composition of alfalfa is to be found in Table 49 of the Appendix. It is to be noted that alfalfa hay contains an average of about 15.4 per cent of crude protein. It is known as a high protein roughage. In comparison with other hay crops, it also contains a high percentage of calcium.

Areas of Alfalfa Production. The wide-spread adaptation of alfalfa in the United States may be observed in Fig. 114. By adjusting soil conditions and by using the various types of alfalfa that are available, it has been found possible to grow alfalfa over a wide range of conditions.

Alfalfa-Production Statistics. By areas, the greatest acreage of alfalfa for hay occurs in the north central region of twelve states, in which an average of 6,406,000 acres were devoted to this crop during

the period 1927 to 1936. The years 1937 and 1938 show about a million-acre increase over this average. The western region is of next importance, growing an average acreage of 4,700,000 acres for the period 1927 to 1936.

In the year 1938, approximately 13,462,000 acres of land in the United States were devoted to the production of alfalfa for hay.

During the period 1927 to 1938, the average production of alfalfa seed in the United States was about 926,440 bushels. The leading states in alfalfa-seed production are Idaho, Arizona, Kansas, Montana, Utah, and Nebraska.

Alfalfa Research. The following material from Senate Document 65, Regional Reesarch Laboratories, provides information relating to research with alfalfa.

Agricultural Research

1. Comparative studies of the yields and economic qualities of standard and new or regional varieties and strains, including lines of common and hairy Peruvian alfalfa.

2. Development of disease-resistant strains by breeding and selection and testing for productivity, cold and wilt resistance, or other characteristics of economic value.

3. Studies on the influence of variety, soil type, soil amendments, cultural practices, stage of maturity, age of stands, and harvesting methods on the general quality and protein content of alfalfa.

4. Experiments on the production of crops of high protein content and high energy value.

Curing and Processing

5. The effects of different conditions of field curing, artificial drying, baling, and storage on the quality and feeding value of alfalfa and the losses of dry matter, nutrients, and vitamins in the preservation of alfalfa through curing and storage. These are all being studied but need much more attention.

6. The efficiency of the trench silo for preservation of alfalfa and other forage, as measured by chemical means and by the utilization of the nutrients by cattle; also the development of new methods for making ensilage by addition of acids and carbohydrates.

Nutrition

7. Studies on the nutritive value of various grades of alfalfa and alfalfa derivatives for growing chicks and poultry; the efficiency of alfalfa hay as a sole ration for dairy cattle and its relation to sterility; the influence of alfalfa on the vitamin D potency of milk; efficient mixtures of protein feeds including alfalfa meal for growing and fattening swine and other animals; the biological value of the various proteins of alfalfa; the effects of cottonseed meal and cottonseed hulls versus those of white corn and alfalfa hay on the quality

and palatability of beef; the effects of dried and preserved alfalfa and other forage on the nutritive value of milk; and the effect of sulfur dioxide in the atmosphere on the production and nutritive value of alfalfa.

8. Investigations on the general factors affecting the vitamin content of alfalfa and the stability of the carotene of alfalfa meal and of vitamin A from added cod-liver oil in mixed rations.

Fundamental Chemical Research

9. Quantitative studies on occurrence of vitamin A, carotene, and other food supplements in alfalfa.

SWEET CLOVER

Sweet clover has become recognized as a valuable forage crop. It is well adapted to use in pasturing livestock, as a hay crop, and as a green-manuring crop. Although sweet clover is grown to the greatest extent on soils deficient in organic matter, yet it is very valuable on soils in a highly improved condition, when used for hay or pasture.

Sweet clover may be used very profitably in many cropping systems if care is exercised in production practices.

Climatic and Soil Factors. Sweet clover will grow under a wide range of soil and climatic conditions. It is adapted to humid regions, yet it has been found to be drought-resistant. Sweet clover requires a neutral or alkaline soil, and therefore it is very important to inoculate the seed if the crop is to be grown on land which has not previously grown sweet clover.

Rotations and Fertilization. Sweet clover may occupy the same place in common rotations in the Corn Belt and Northern States as red clover. Depending upon conditions, sweet clover may respond profitably to the use of phosphorus and potash fertilizers, and manure may be of distinct value in securing a stand.

Seeding Sweet Clover. Best seeding results usually are obtained in early spring by seeding sweet clover alone or on fall-sown wheat or rye, or with barley or oats. If seeded with barley or oats, best results are secured by planting with only a bushel of the barley or oats used as a companion crop. Twelve to fifteen pounds of scarified sweet clover per acre are generally sufficient. Sweet clover seeds have a hard seed coat; hence germination is increased by the scarification process, which abrades and thins the seed coat.

If unscarified seed is used, 15 to 20 pounds are necessary per acre; and of unhulled seed, 20 to 30 pounds. When unhulled seed is

planted, it is usually planted in late fall so that winter action will crack the seed coat for satisfactory germination during the spring.

Harvesting for Hay or As Seed. Sweet clover should be cut for hay just before the blossom buds appear. If bloom is allowed to show before cutting, a coarse, woody hay usually results. If cut sufficiently early, a high quality, leafy hay can be obtained from sweet clover. The mower bar must be set high enough to leave a

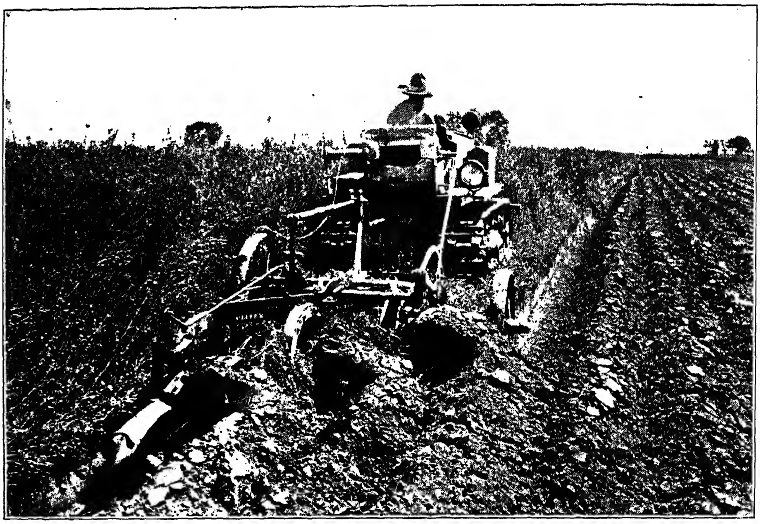


FIG. 115. A vigorous stand of sweet clover, when plowed under, helps to supply the soil with humus. (*Colorado Agricultural Experiment Station.*)

6- or 8-inch stubble, in order that a good second growth may result. The second year's growth of sweet clover does not arise from a crown, but propagates from buds in the axils of the branches and leaves on the lower portion of the stalk; hence a sufficiently long stem for numerous new branches must be left. If the mower bar is raised by means of specially made shoes at either end, results are more satisfactory.

Sweet clover hay is somewhat more difficult to cure properly than alfalfa. It should be allowed to wilt in the swath for four to six hours, then windrowed with a side-delivery hay rake, and allowed to cure in windrows for a day or longer. Under exceptionally good hay-making conditions, curing may be accomplished in the windrows, but it is usually necessary to throw hay into small cocks after curing in the windrows for a day or so. The hay is left in the cocks until

cured. Curing requires two or three days or as much as a week, depending upon weather conditions.

Handling in this way prevents large losses of leaves. The leaves are nearly three times as rich as the stems in protein; hence sweet clover hay should be harvested at the right time and handled in the proper manner to give the highest percentage of leaf.

Since the sweet clover plant does not mature all its seed at one time, it must be cut when 60 to 75 per cent of the seed pods is brown and before there has been much loss from shattering. Usually the grain binder is used in harvesting. The crop should be harvested for seed when toughened by dampness due to light mist or dew. The sheaves should be placed in small open shocks for curing.

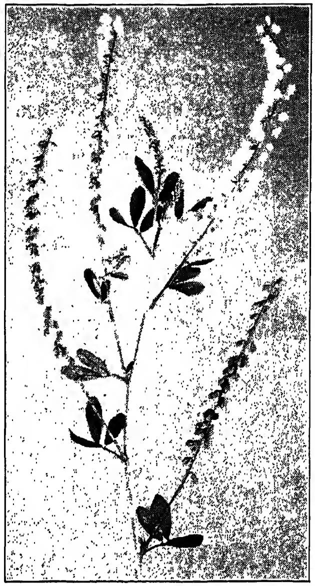


FIG. 116. The illustration presents the buds, flowers, and seeds of sweet clover. (*Illinois Agricultural Experiment Station.*)

The ordinary grain thresher may be used in threshing sweet clover. The hulls are then removed from the seed with a clover huller or sweet clover seed scarifier.

Botanical Classification and Characteristics of Sweet Clover. Sweet clover is an important plant of the *Leguminosae* or pea family of plants. There are twenty or more species of sweet clover native of Asia, Europe, and Africa. In the United States experimental and test work has been conducted with a number of species, but only three or four forms have been found to be particularly useful.

Biennial white-flowered sweet clover, *Melilotus alba,* is probably the most common form used in the cropping systems of this country. It is an erect-growing plant, with smooth stems, trifoliate leaves, and white flowers borne on long flowering stems, or *racemes,* which arise in the axils of the leaves. During the first season, a growth of 18 to 30 inches is attained under good conditions and an abundance of reserve food is stored in large, thickened roots. During the second year, a many-branched growth starts from buds on the crown of the plant. A growth of 4 to 8 feet may occur the second year.

M. alba annua is an annual form of sweet clover, commonly referred to as Hubam sweet clover. It is similar in general form to the biennial white sweet clover except that it flowers and produces seed, thus completing the cycle of its growth in one season.

M. officinalis is the common yellow-flowered biennial form of sweet clover. It has the same general characteristics as the biennial, white-flowered type except that it has yellow flowers, blooms and matures earlier, produces more leaves, has finer stems, and does not grow so tall and coarse.

M. indica is a yellow-flowered annual form of sweet clover which appears to have some use under warm conditions in the Southern and Western States.

CHAPTER XXIII

RED, ALSIKE, AND WHITE CLOVERS

The clovers, where adapted, are foundational crops in farming. They increase the humus and nitrogen supplies of soil, help prevent erosion, and provide high quality hay and pasture.

RED CLOVER

Red clover, *Trifolium pratense,* is primarily biennial in habit although some plants in a stand may live until the third season. This clover has a tap root with extensive laterals. The American type has hairy stems and leaves. The inflorescence is ovate in shape and consists of 50 to 150 purplish-red florets per head. Clover florets are normally cross-pollinated with the aid of insects. Bees are chiefly responsible for pollination.

FIG. 117. Red clover is one of the most important legumes in the rotations of the Corn Belt and the dairy regions. *(Ohio Agricultural Extension Service.)*

Varieties. According to the 1937 Yearbook of Agriculture (177), red clovers, both in Europe and North America, fall into two classes—(1) early, or double-cut, those giving two hay crops in a season; and (2) late, or single-cut, those giving but one hay crop in a season. There are several strains or forms within each of the two classes. *T. pratense perenne* is what is known as mammoth red clover. This clover is similar in appearance to common red clover, but it produces but one crop a season, matures later, and is larger and coarser in its growth.

Composition of Red Clover. Red clover produces a very high quality hay. The nature of its composition may be judged by referring to Table 49 of the Appendix.

Red-Clover Production Statistics. The areas of red-clover production are illustrated in Fig. 118.

During the period 1927 to 1936 an average of 25,189,000 acres per year of clover and timothy hay were harvested. This may be compared to an average of about 12 million acres per year for alfalfa during the same period. The most important states in clover-seed production are Indiana, Ohio, Illinois, Michigan, Iowa, Wisconsin, and Minnesota.

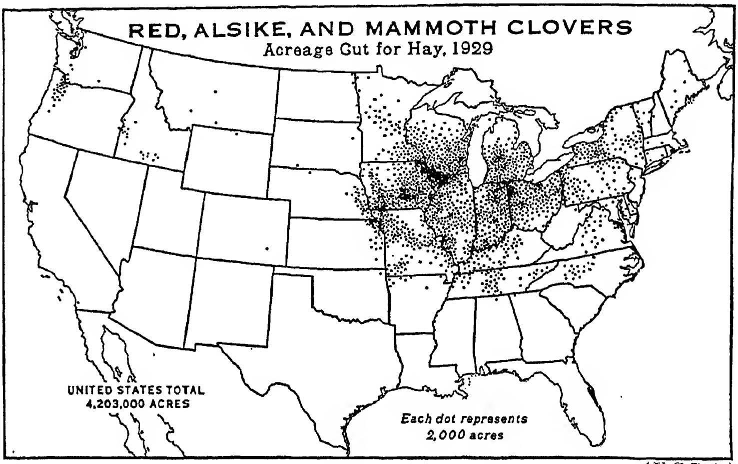


Fig. 118.

Red-Clover Production Factors and Practices. The climate best adapted to the growth of red clover is revealed in Fig. 118. Well-drained soils, those which are reasonably fertile, and those which range in *p*H from 6.0 to 7.0 are satisfactory. This crop responds particularly to applications of lime and phosphorus. A Tennessee Station report (105) points out that, in large areas in Tennessee, clover responds profitably to applications of 300 pounds of 16 per cent superphosphate or its equivalent. The Michigan Station (28) suggests the use of about 250 pounds per acre of 16 per cent superphosphate. On sandy soils and lighter sandy loams it is recommended that such fertilizers as 0–12–6 or 0–14–4 be used. Clover is

usually fertilized indirectly as the fertilizer is applied to the companion crop or to other crops in the rotation, and the clover crop responds to the residual or holdover effects of the fertilizer.

Red clover is one of the most important legumes in the rotations of the Corn Belt and the dairy regions. Because of its biennial characteristics, it is remarkably well adapted for seeding with companion crops. When the companion crop is removed, the clover acts as a cover crop for the succeeding autumn and winter periods and produces hay or pasture the next growing season.

It is important to use red-clover seed that is of high vitality, and free fom mixtures and noxious-weed seeds. The most important factor in seed quality, however, is adaptation. Since the seed of unadapted strains cannot be told from adapted strains in appearance, it is extremely important to know the source of the seed.

In red-clover strain tests by the Ohio Agricultural Experiment Station, in cooperation with the Division of Forage Crops and Diseases of the United States Department of Agriculture (56), it was found that all the European and South American red-clover strains were damaged by anthracnose and other diseases or by the attack of leafhoppers. Red clover from seed produced in the United States suffered less damage from the same troubles. It was also determined that the second growths of the European and South American red clover were inferior to those from domestic or Canadian seed. In winter hardiness the red clovers from Ohio, other central states, and from Canada were much superior to the clovers from Europe and South America.

At the Tennessee Station (105) it was found that red-clover seed from Bohemia resulted in a 10 per cent stand; from Chile, 20 per cent; from France, 50 per cent; from Germany, 50 per cent; and from Italy, practically no stand. In comparison, nearly full stands were secured from Tennessee resistant and Ohio-grown red clover.

Many states have conducted tests with red clover which demonstrate the great importance of using adapted seed.

Dr. E. A. Hollowell of the Division of Forage Crops, United States Department of Agriculture, points out the bad effect of using unadapted foreign seed. After such seed is once planted it loses its identity, and seed from the surviving plants cannot be distinguished from adapted seed. The mechanical mixture of adapted and unadapted seed lowers the quality of seed, but of greater concern is the cross pollination and fertilization which occurs. Such cross breeding reduces the quality of the adapted strains. Dr. Hollowell indicates the importance of parentage in judging the true value of seed.

FIG. 119. Unadapted Italian red clover (above). Adapted domestic red clover (below). Great losses result from using unadapted seed. (*Illinois Experiment Station.*)

The usual rate of seeding red clover is 8 to 10 pounds per acre when sown alone. In mixtures it may vary 3 to 8 pounds.

Red-clover seed may be broadcast or drilled, depending upon soil and moisture conditions. It is usually seeded in early spring on fall- or spring-sown companion crops. August seedings or late summer seedings may be successful if the proper seed-bed conditions can be secured. The object in seeding practice is to place the seed about $\frac{1}{2}$

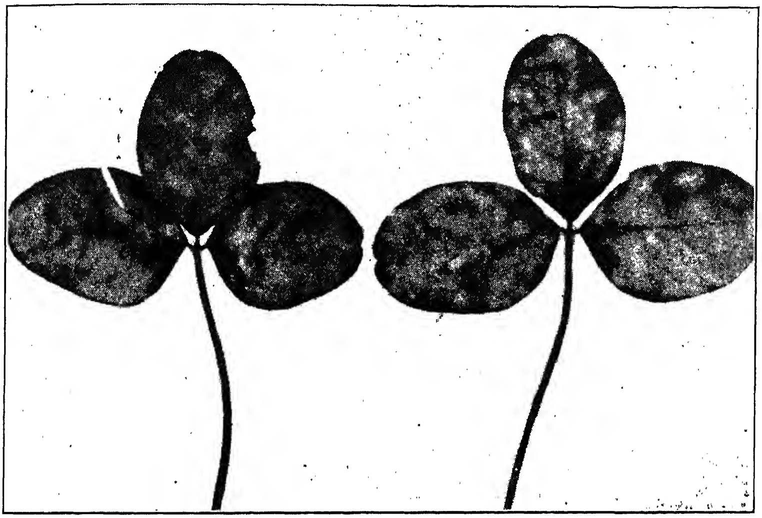


FIG. 120. The leaves of red clover often become infected with a disease commonly called powdery mildew. (*Ohio Agricultural Extension Service.*)

to $\frac{3}{4}$ inch deep in a well-prepared, compact seed bed. If sown early in the spring when frost action has "honey-combed" the soil, the freezing and thawing of the soil will cover the seed sufficiently for good results.

Red clover is usually cut for hay when in full bloom or just past this stage. Heavy yields may be secured if the red clover is cut at a time when one-third of the heads are brown, but the quality of the hay is appreciably less than if cut earlier.

In curing red-clover hay, it is essential to adjust practices to the end that the leaves of the hay are saved and good color is preserved.

When common red clover is cut for seed, it is important to cut the first crop not later than full bloom, and somewhat earlier may be desirable. Such a practice usually promotes the development of a vigorous second crop for seed. Cut for seed when the heads have

turned brown. After cutting, the crop is cured in small piles. Losses from seed shattering may be reduced by cutting and handling under slightly damp conditions.

ALSIKE CLOVER

Alsike, *Trifolium hybridum,* is a short-lived perennial clover, native to northern Europe and grown extensively in Sweden. In this country it has been found to be winter hardy in that it will withstand winter conditions which cause severe injury to red clover.

Alsike clover requires abundant moisture and a cool climate. It does well on a wide variety of soils but makes its best growth on heavy soils. Alsike clover is more tolerant of acid soil conditions than is red clover and will do better than red clover in poorly drained or wet areas.

Alsike is usually seeded at the rate of 4 to 6 pounds per acre. It is commonly seeded in combination with timothy, with red clover, or in a mixture of the three crops. Alsike hay is excellent in quality.

Alsike clover makes a good pasture crop although, like red clover, it may cause bloat in cattle. Alsike is somewhat erect in growth, branching, and has smooth hollow stems. It usually grows 18 to 24 inches in height. The flowering heads of alsike may be white or pink.

WHITE CLOVER

White clover, *Trifolium repens,* is a perennial type of clover particularly well adapted for use as a pasture plant. A number of rather distinct forms are recognized. A Vermont Station publication (102) lists four as follows: common white Dutch; ladino or mammoth white; English wild white; indigenous or natural wild white clover.

The common white Dutch clover is most often used for pastures and lawns because the seed is relatively inexpensive. It is characterized by larger leaves, fewer runners, longer growing season, earlier blooming, and later fall growth than the wild white types. It is something of an intermediate form between the wild white types and ladino.

The mammoth white or ladino clover had its origin in northern Italy. It has an erect habit of growth which, combined with its large leaves and long stems, causes it to grow well in competition with tall grasses. This type does not form a compact turf and it is not well adapted to heavy or close grazing.

In Great Britain, the common type of pasture clover is the English wild white clover. This white clover forms a compact turf, is characterized by short stems, short internodes, and small leaves. It is well adapted to close grazing, in England spreads rapidly, is persistent and long-lived.

As indicated in the Vermont publication (102), the wild white clover appears to have been native in Europe and was brought to this country by early settlers. It is found in old permanent pastures and seems to come in naturally when conditions for its growth are favorable. In Vermont this clover generally appears intermediate in growth habits between the small English wild white and the common white Dutch clover. A variety of types are found in American-grown seed.

Experiments with common white Dutch clover, ladino, English wild white clover, and the natural wild clovers, conducted at the Vermont Station, indicated that with various methods of fertilization, the natural wild white clover outranked the others in respect to persistence and longevity. The English type needed and withstood close grazing, while the ladino disappeared quickly when closely grazed. The ladino outyielded the other clovers while it lasted.

CHAPTER XXIV

SOYBEANS AND FIELD BEANS

SOYBEANS

The many uses of soybeans, particularly the value of the crop as a leguminous feed and the use of soybean oil and meal for many manufactured products, have caused it to develop from a minor crop to a crop of importance in most states where corn is grown. Because of the growing importance of soybeans as an American crop, it is essential to give detailed attention to the factors and practices relating to the production of soybeans.

Climatic and Soil Factors in Soybean Production. While soybeans are grown in many of the states from Iowa and Missouri eastward and southward to the Gulf States, the most important areas of production are in Illinois, Iowa, and Indiana.

Soil and climatic conditions favorable to corn production are usually well suited to the growing of soybeans. This crop is more tolerant of acid soil conditions than is red clover.

Soybeans may respond to phosphorus and potash fertilizers, but, in general, they are not fertilized directly, using fertilizer residues from materials applied to other crops in the rotation.

Soybeans in Rotation. Many Corn Belt rotations now contain soybeans as a regular part of the cropping systems. The soybeans are preceded by corn and succeeded by small grains seeded to clover or grass. A rotation of corn, soybeans, wheat, and clover is rather typical.

Often it is difficult to remove the soybean crop early enough to permit planting winter wheat at the proper time. The early planting of soybeans or the use of earlier varieties may need to be resorted to at the expense of soybean yields in order to use winter wheat in the rotation. Soybeans may be followed by rye or, on lands where erosion is not an important factor, soybeans may be followed by spring grains.

Varieties and Seed Qualities. Investigations with soybeans have demonstrated the need for locally adapted varieties suitable for different purposes. Soybeans seem peculiarly sensitive to soil and climate conditions, and therefore it is very important to secure suitable varieties which have been tested under local or similar conditions.

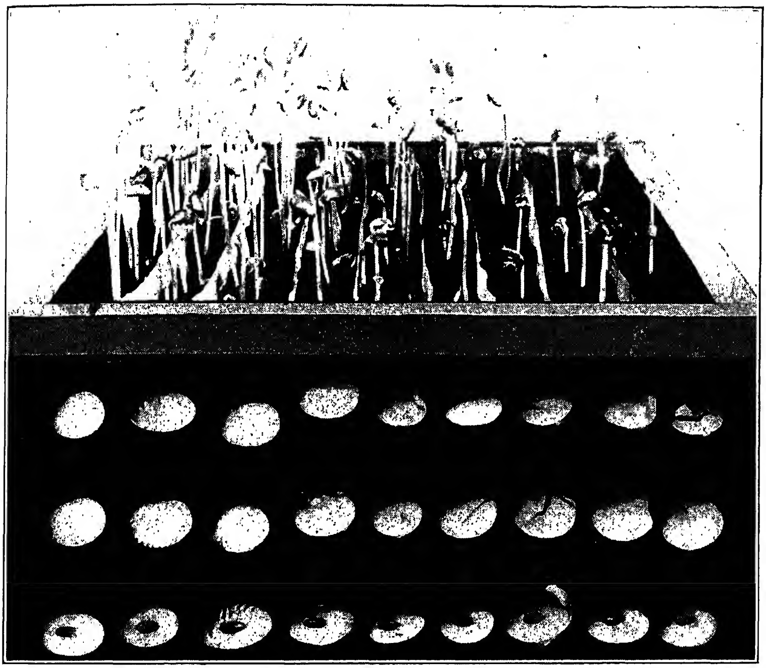


FIG. 121. Shriveled and broken seed coats and broken beans reduce the germination of soybeans. The beans on the left are of high quality. Those to the right are progressively less desirable. (*Ohio Agricultural Extension Service.*)

The recommendations for various states are to be found listed in Table 51 of the Appendix.

For planting purposes, seed should be tested for germination shortly before planting or a record of a recent germination test should be used. Avoid seed that is damaged, for broken seed coats or broken beans reduce germination. The seed should be true to variety and free from variety mixtures, seeds of other crops, and weed seeds.

Seed-Bed Preparation. A seed bed prepared in the same manner as for corn is suitable for soybeans. It is very essential to use pro-

cedures which will destroy as many weeds as possible previous to planting.

Inoculation. Soybeans, inoculated, yield substantially more than when uninoculated. It is therefore essential to inoculate the seed if there is any doubt whether the soil carries the appropriate organisms.

Planting Soybeans.—Early plantings, just before or at the time of corn planting, ordinarily result in somewhat higher yield and earlier

FIG. 122. The root of a soybean plant which shows the nodules resulting from inoculation. (*Ohio Agricultural Extension Service.*)

ripening. According to Ohio investigations (112), the first half of May represents a suitable time for planting soybeans in Ohio, and results in Illinois (18) indicate similar dates. In general, it may be said that the early part of satisfactory corn-planting time is also suitable for planting soybeans.

The recommendations as to rate and method of seeding are rather variable. At the Ohio Station (112), 2 bushels of seed seem to give best results when soybeans are drilled solidly. When planted in 28-inch rows, 3 pecks give the best yields. The Illinois Station (18) recommends about 1½ bushels for solid drilling and 1 bushel when the crop is drilled in 24-inch rows. If seed is not high priced it is

recommended that these rates be increased somewhat, as there is a fair possibility of increasing the yields to some extent.

The Kansas Station (191) reports experiments in which soybeans, planted as late as the tenth of June at Manhattan, matured only three or four days later than the same varieies planted three weeks earlier. June 1 to 10 seems best in this section. Usually a heavier

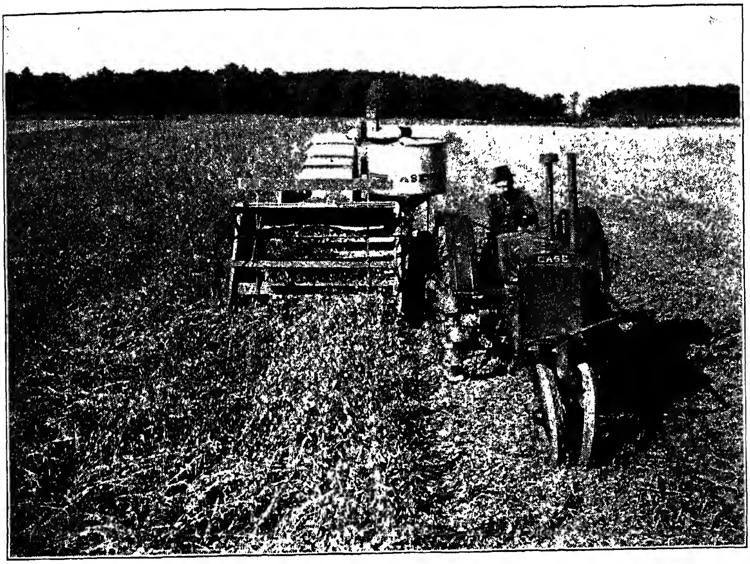


FIG. 123. The harvester-thresher or combine is used extensively by farmers who grow soybeans for the seed crop. (*J. C. Allen and Son, West Lafayette, Indiana.*)

yield of hay will be produced in this state when the crop is planted two weeks earlier.

Cultivation of Soybeans. When soybeans are drilled solid, it is essential to cultivate and prepare the seed bed in a manner that will destroy as much weed growth as possible. The rotary hoe, harrow, and weeder may be used to break soil crusts and to destroy weed growths during the early stages of the crop growth. When soybeans are planted in rows, the same implements may be used but, in addition, row cultivators may be adjusted and used effectively.

Harvesting Soybeans. When soybeans are harvested for market beans, there are a number of ways to handle the crop. One of the best methods is to use the combine harvester. The crops should be thoroughly ripe and the beans should have a moisture content of

15 per cent or less, unless a special means of drying is available. The speed of the cylinder should be reduced to about one-half the speed used in threshing wheat, while the remainder of the machine should operate at the usual speed. Combining saves time, saves beans, and spreads the straw.

The grain binder may be used and the crop handled in much the same manner as with small grain. Mowers may also be used with a

Fig. 124. Large acreages of soybeans are cured each year for use as hay. (*J. C. Allen and Son, West Lafayette, Indiana.*)

side-delivery attachment to move the swath out of the way. This process is followed by raking and cocking. When using the binder or mower methods, it is necessary to take extra precautions to save the beans from shattering.

Special soybean harvesters have now been made available.

If harvesting for hay, soybeans are usually cut with a mower when the lower leaves are just beginning to turn yellow and the seeds in the pods are about half filled. The crop is partially cured in the swath, and then windrowed and cocked.

Storage. Soybeans are not safe in bulk storage unless the moisture content is down at least to 15 per cent. If beans contain more moisture, they should be spread out and stirred frequently or they should be cross-piled in open-meshed bags. Sometimes the beans may be

dried by standing bags in rows in a shed that provides plenty of ventilation.

Soybeans and Soil Productivity. The question of the effect of soybean production on the soil is often raised. From extensive investigations at the Illinois Station (147), it has been concluded that serious soil erosion-control problems arise when soybeans are grown on rolling land. In cultivated rows they present much the same problem as corn and, when drilled solid up and down the slopes, the erosion is reduced about one-half. The best control of erosion is secured by drilling soybeans solid on the contour and then following with a winter cover crop drilled on the contour.

The Illinois experiments also reveal that the effect of soybeans on the nitrogen content of the soil depends largely upon the use of the crop. Nitrogen supplies will be depleted unless part of the tops are returned to the soil. Combining the beans and leaving the straw on the land may cause a slight increase in the nitrogen content if the nitrogen which is added is not lost through leaching before being used by the succeeding crop. It is concluded that soybeans should be considered primarily as a cash or feed crop and that other legumes should be used for soil-improvement purposes.

Utilization of Soybeans. Soybeans are used for a great many purposes. Table 32 from the Yearbook of Agriculture, 1937, presents in diagram form the many uses to be made of soybeans.

Botanical Classification and Characteristics of Soybeans. The soybean belongs to the *Leguminosae* or pea family of plants and is usually referred to as *Soja max,* although another name, *Glycine max,* is occasionally used.

The soybean is normally self-pollinating. Natural crossing sometimes may occur. The flowers may be white or various shades of purple. The stems may be green or purplish in color, and the stems, leaves, and pods of most soybeans are hairy or pubescent. Soybeans have rather vigorous roots with branches which often extend into the soil to a depth of 4 or 5 feet.

Origin and History. Early Chinese records indicate that soybeans were being used long before the time of the earliest written records. It appears that cultivated soybeans may have been derived from a wild type now found in much of eastern Asia. Since about the year 1890, the agricultural experiment stations of the United States have carried on investigations with soybeans.

TABLE 32

Soybean Utilization

- Soybean
  - Plant
    - Forage
    - Green manure
    - Pasture
      - Fuel
      - Furfural
      - Hay
      - Silage
      - Soilage
  - Bean
    - Meal
      - Celluloid substitutes
      - Core binder
      - Feeds
        - Cattle
        - Dogs
        - Fish
        - Hogs
        - Poultry
        - Rabbits
        - Sheep
      - Fertilizer
      - Glue
      - Human food
        - Beer brewing
        - Flour (*see* Dried bean)
        - Seasoning powders
        - Soy sauce
        - Vegetable milk
      - Plastics
      - Water paints
    - Oil
      - Candles
      - Celluloid
      - Core oil
      - Disinfectant
      - Electrical insulation
      - Enamels
      - Food products
        - Butter substitutes
        - Cooking oils
        - Lard substitutes
        - Salad oils
        - Medicinal oil
      - Fuel
      - Glycerin
      - Insecticides
      - Lecithin
        - Candies
        - Chocolate
        - Cocoa
        - Emulsifier
        - Margarine
        - Medicines
        - Textile dyeing
      - Lighting
      - Linoleum
      - Lubricant
      - Oilcloth
      - Paints
      - Printing ink
      - Rubber substitutes
      - Soaps
        - Hard
        - Liquid
        - Soft
      - Varnishes
      - Waterproof for cement
      - Waterproof goods
    - Green bean
      - Canned
      - Frosted
      - Green vegetable
      - Salad
    - Dried bean
      - Baked
      - Boiled
      - Breakfast foods
      - Feeds
        - Cattle
        - Hogs
        - Poultry
        - Sheep
      - Flour
        - Baked products
        - Breakfast foods
        - Candies
        - Chocolate
        - Diabetic foods
        - Health drinks
        - Ice-cream cones
        - Ice-cream powder
        - Infant foods
        - Macaroni products
        - Meat products, filler
      - Roasted
        - Candied
        - Coffee substitute
        - Salted
      - Soy sauce
      - Sprouts
      - Vegetable milk
        - Casein
          - Paints
          - Paper size
          - Textile dressing
          - Waterproofing
        - Condensed
        - Curd
          - Canned
          - Dried
          - Fermented
          - Fresh
          - Smoked
        - Foods
        - Powder

Varieties of Soybeans. There are a large number of soybean varieties. Those recommended by many states are to be found in the list of varietal recommendations found in Table 51 of the Appendix. Detailed information concerning them may be found in the 1937

FIG. 125. Seeding habits of various types of soybeans. (*Kansas Experiment Station.*)

Yearbook of Agriculture, which contains a list of soybean varieties and their varietal characteristics.

Composition. The composition of soybeans is presented in Table 49 of the Appendix. It is to be noted that soybean hay is high in protein content and that the beans are high in protein and oil or fat content. The cake or meal, which remains after the oil has been removed, contains a high percentage of protein and is used as a protein concentrate in feeding livestock.

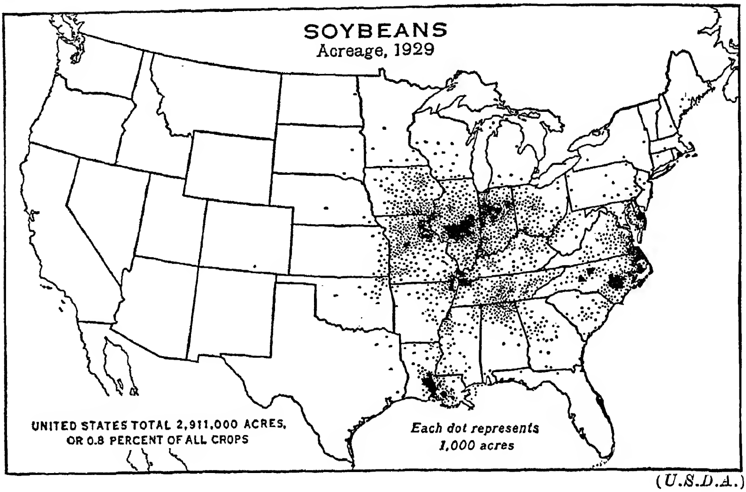


FIG. 126.

Areas of Soybean Production. The areas in which soybeans are grown extensively are illustrated in Fig. 126.

Soybean Production Statistics. The production of soybeans has increased very rapidly in the United States. This development is well illustrated by the facts found in Table 33.

TABLE 33 *

SOYBEANS: ACREAGE, YIELD, PRODUCTION, SEASON AVERAGE PRICE PER BUSHEL RECEIVED BY FARMERS, AND VALUE, UNITED STATES, 1934 TO 1940

Year	Acreage Grown Alone for All Purposes	Total Acreage	Acreage Harvested for Beans	Average Yield per Acre	Production	Price	Farm Value
	(1000 acres)	(1000 acres)	(1000 acres)	(Bushels)	(1000 bushels)	(Dollars)	(1000 dollars)
1934	5,572	5,994	1539	15.0	23,095	1.01	23,281
1935	6,640	7,111	2697	16.5	44,378	.79	35,073
1936	5,811	6,646	2132	14.1	29,983	1.28	38,403
1937	6,171	7,005	2549	17.8	45,272	.84	38,178
1938	7,262	8,196	3105	20.2	62,729	.68	42,376
1939	9,506	10,489	4417	20.7	91,272	.81	74,299
1940	10,528	11,462	4961	16.1	79,837	.76	60,535

* United States Department of Agriculture, Agricultural Statistics, 1941.

In the year 1938, Illinois grew about 2,118,000 acres of soybeans; Iowa, 950,000; Indiana, 828,000; Ohio, 445,000; and Missouri, 320,000. Mississippi, the leading state in the South, grew 560,000 acres in the year 1938, followed by Arkansas, Alabama, Tennessee, and Louisiana.

Soybean Research. The scope of the present program of research, dealing with soybeans, is presented in the following from Senate Document 65 (130).

Considerable research is being conducted at the present time in an effort to solve many of the difficulties attending the introduction of a relatively new crop and new products into American agriculture and industry.

The processing of soybeans is principally carried out by two methods, namely, pressing and solvent extraction. In either case the beans are cracked, flaked, and conditioned with respect to moisture and temperature prior to the separation of the oil. The meal produced by either of these processes may be used directly as feed for livestock or processed further by heat or other treatment to increase its digestibility. The oil is usually clarified by settling or centrifuging and may or may not be further refined, bleached, and deodorized prior to its entrance into industrial channels.

Research work on the utilization of the products derived from soybeans naturally falls into two classes, namely, that pertaining to the oil and that pertaining to the meal or protein. Furthermore, the research on the oil can be subdivided into studies pertaining to its use in (*a*) drying-oil industry, (*b*) edible-oil industry, (*c*) inedible-oil industry.

The followng description of this research is subdivided into several categories.

Agricultural Research

1. Genetic studies, particularly with reference to the effect of selection and hybridization on the chemical composition and the forage, feed, food, and industrial uses of soybeans and derived products.

2. Investigations of the effect of date of planting, method of seeding, rate of seeding, soil and fertilizer treatment, environmental factors and stage of maturity on yield, and chemical composition of soybeans.

3. Investigations of the relations of color of seedcoat and effect of seedcoat injury on the germination, growth, storage, and composition of beans.

4. Investigation of the chemical composition and industrial uses of different varieties of soybeans and their derived products; also the extraction of phospholipides from the oil.

5. Analysis of soybeans to determine the variation in chemical composition resulting from differences in variety, soil type, fertilizer treatment, and other cultural conditions.

6. Studies of the type of equipment and methods of harvesting on the yield, quality, and composition of soybeans.

7. Investigation of the relative values of soybeans for forage, commercial seed, and vegetable purposes; also the food quality of such products as soybean milk, milk curd, and milk residue.

8. Studies on the respiration of soybeans, and the effect of storage methods and environment on the germination, composition, and chemical and physical properties of the beans and their derived products.

9. Study of the quantity and quality of oil and protein in soybeans in relation to grading factors defined in the United States Standards.

10. Analysis of the factors affecting prices of soybeans, and the investigation of the competition and interchangeability of other fats and oils with soybean oil.

Processing

11. Studies on the variation in the release of oil by different varieties of soybeans and by the use of different solvents; also similar studies with respect to the water-soluble protein.

12. Studies of the design, specification, and installation of semi-plant scale equipment for both the expeller- and solvent-extraction methods.

13. Processing of beans under controlled conditions to provide standardized products for further research.

14. Investigation of the effect of various solvents and conditions of operation on the yield and quality of meal and oil for special industrial applications.

15. Heat treatment of solvent extracted meal to improve its digestibility as a livestock feed.

16. Investigations of the effects of variations in processing (including refining, bleaching, and deodorizing) on the physical and chemical properties of soybean oil, especially color and odor.

Utilization of Oil

17. Investigation of methods of improving the drying property of soybean oil by chemical and physical methods, including treatment with oxidizing agents, acylation, use of catalysts, heat bodying, etc.

18. Studies of the drying rate and durability of resultant films of mixtures of soybean oil with tung, perilla, linseed, oiticica, hempseed, and similar oils, before and after high-temperature treatments for short periods. Investigation in this field has led to date to the production of commercial paints containing up to 35 per cent soybean oil, especially red barn paints with soybean and perilla oil, roof and freight car paints with soybean-hempseed oils, and some aluminum paint for interior and exterior use. A considerable amount of this oil is also used in oil mixtures for the preparation of so-called second-line house paints.

19. Studies on the formulation, drying rate, gloss retention, water resistance, durability, and related properties of paints, varnishes, and interior enamels produced with soybean oil and with mixtures of soybean and other more rapid drying oils.

20. Investigation of the production properties, and uses of synthetic resins derived from soybean oil and from soybean oil fatty acids.

21. Studies of the use of soybean oil as a core-binding material for use in foundry work.

22. Investigation of the effects of temperature, pressure, and catalysts in the selective hydrogenation of soybean oil and their relation to the stability of the finished product.

23. Studies in the sulfation and phosphorization of soybean oil for use as a fat-liquoring oil and as a driving oil for the soaking of silk in the place of imported olive oil. Work thus far has been confined to a study of the degree of sulfation and methods of neutralizing and washing the oil after treatment with sulfuric acid.

24. Investigation of the use of soybean oil in soft soaps and special detergent agents.

25. Separation of phosphatides and sterols from crude soybean oil by various methods and studies on the uses of crude and semipurified phosphatides as fat stabilizers, emulsifying agents, etc.

26. Studies on the effect of soybean oil in admixtures of bituminous materials and as primers to improve the surface properties of hydrophilic stones to prevent stripping of asphalt in pavements.

Utilization of Protein

27. Investigation of methods for the production of purified proteins from soybean meal and a study of their physical and chemical properties.

28. Laboratory and semiplant scale studies of methods of extracting various proteins and protein fractions, together with practical studies of the application of these products to the production of (*a*) adhesives for use in the manufacture of briquets, (*b*) glues for fabricating plywood and laminated papers, (*c*) modified resin sizes for wall paper and other papers, (*d*) binder for china clay in the coating of high-gloss book, magazine, and label papers, (*e*) cold-water paints, (*f*) retarder for gypsum plasters, and many other products.

29. Investigation of methods and materials for the production of plastics from soybean meal and protein, especially in combination with phenol-formaldehyde, urea-formaldehyde, and other resins. Also studies on plasticizing and waterproofing agents for use in soybean plastics.

30. Investigation of the production of uniform and ash-free fractions of soybean protein for use in the production of synthetic fibers. Studies of the effect of variation of viscosity, H-ion concentration, and aging of protein solutions in fiber-spinning operations.

31. Studies on the production of soybean meal and protein for use as a foam stabilizing agent for beer, creaming agent for candy, adjunct in the production of brown or golden color in bakery products, precooked cereals, and dog food.

Fundamental Research

32. Studies on the fundamental composition of soybean proteins, including investigation of the carbon, hydrogen, nitrogen, sulfur and oxygen ratios as

well as the constituent amino acids and comprising the protein molecule and their relation to its spinning properties.

33. Investigation of the chemical composition of the glycerides and derived fatty acids of soybean oil especially by means of molecular distillation, solvent fractionation, and the distillation of esters and free acids.

34. Studies on the isolation and characterization of soybean carbohydrates with particular reference to sucrose and stachyose.

35. Investigations of the enzyme systems of soybeans, particularly with reference to the isolation, identification, and industrial application of amylase.

36. Investigation of existing methods and development of new methods and techniques for the analysis of soybeans and their derived products.

FIELD BEANS

Field beans, *Phaseolus vulgaris*, have long been popular food in American homes.

During recent years, the development of the canning industry has increased the demand for beans and the variety of ways in which they are offered for food. Further increase in the demand for field beans can be expected from year to year as the population increases and new uses for the crop are developed.

Leading Commercial Varieties. The navy bean, or common white pea bean, is produced in the greatest quantity and is the most widely distributed. This bean is of American origin, and became known for the first time to white men when the territory which is now New York State was settled. The Iroquois Indians grew this small, round, white pea bean with corn. The "Indian bean" rapidly became a favorite with the early settlers. Later, it became known as the "navy bean," because of the large demand which developed for this bean for naval and marine food-supply purposes. The navy bean, when properly matured and dried, has remarkable keeping qualities. Appropriately it may be called the "army bean," since it furnishes one of the important foods of our army.

The navy bean is an important crop in those parts of the Lake States which are favorable to its growth. It has become one of the chief cash crops in Michigan, which leads in the production of navy beans, as well as in New York and Vermont. These beans are also produced in quantity in California, Colorado, and Idaho. Navy beans are of two types: the white pea bean, almost round in shape; and the medium bean, somewhat larger and more oval.

In Michigan, New York, Wisconsin, and Minnesota, the Robust variety has given the highest results in yield tests. It is a medium

pea bean, developed by Professor F. A. Spragg, of the Michigan Experiment Station. The Robust is resistant to blight and anthracnose, and apparently immune to mosaic, a bean disease that causes much loss in New York State and is present also in Michigan.

The red kidney bean is next in importance in Michigan, New York, and Wisconsin. This bean is used mostly for canning purposes, and the supply has been less than the demand for the past five years. White kidney beans are adapted to the same territory but do not meet with the strong demand of the red kidneys.

In New York, the Wells Red Kidney is strongly recommended because of its resistance to anthracnose. The Wells Red Kidney is a development of the plant-breeding work at the Cornell Experiment Station.

The marrowfat bean, a white bean larger than the navy bean, is grown chiefly in New York and New England for eastern consumption. The Boston Yellow Eye is another Eastern variety grown to a somewhat limited extent for local consumption. In California, the Black Eye, Pinto, Tepary, and navy bean are most widely grown. Lima beans, both dried and for canning, are produced to a large extent in southern California.

The Great Northern, grown chiefly in Idaho and Montana, has achieved great commercial importance during the past decade. It is a white bean, larger and longer than the common navy, and has excellent cooking qualities.

Beans Not a "Poor Soil" Crop. The common saying, descriptive of poor lands, that "they are too poor to grow beans," did not originate among farmers who knew beans. The soils of the best bean districts of New York and Michigan are fertile loams, silt loams, and clay loams of the glaciated lake-bed areas. They are moisture-retentive soils, well supplied with organic matter and the mineral elements of fertility, particularly calcium. In California, the best bean soils are the fertile, water-deposited soils bordering the sea in southwestern California. The bean-producing area is further limited by the peculiar seasonal requirements of the crop. A uniform growing season, characterized by cool nights, ample rainfall, and a high humidity, is needed for beans. This crop, therefore, is restricted to areas of desirable soils in the region of the Great Lakes and bordering the sea. In the Corn Belt, though the soil may be well suited to beans, the crop fails to give profitable results because of the hot, dry spells which frequently occur during the growing season and prevent the suitable filling of the pods.

Beans are not adapted to acid or sour soils, and on muck soils and poorly drained clays they are inclined to mature too late and to suffer great loss from disease injury and frost.

Plant Clean Seed of the Best Variety To Grow a Big Crop of Clean Beans. Good seed is of the highest importance in bean growing. As a general rule, homegrown beans, which are clean and free of disease, from high yielding fields give best results. The bean diseases—blight, anthracnos, and mosaic—are carried in the seed, hence the necessity of getting seed produced in fields relatively free of these diseases.

Blight is a bacterial disease, which greatly decreases the yield of affected bean fields, and results in a high "pick" of the harvested crop, owing to the presence of a large percentage of dark-yellowish or spotted beans. Injury from blight is lessened by planting clean seed.

Anthracnose is a fungus disease, which also causes a great increase in the pick of the harvested crop and lessens the yield. Infected seed beans show the presence of reddish or brownish spots. Anthracnose is effectively controlled by planting seed from clean fields.

The mosaic disease greatly reduces yields by curtailing plant growth. Beans from affected fields show a high percentage of small, immature, darkened beans. Clean seed from clean fields is the best control measure.

Plant clean, plump, viable seed; cull out discolored, diseased, and immature seed.

Plow Early for Best Results and Prepare Seed Bed Thoroughly. It takes four to six weeks after plowing to get a seed bed in good condition for planting beans. Plowing should be done in the fall or as early in the spring as possible. Early plowing gives opportunity for the seed bed to settle and provides time in which to secure a seed bed comparatively free of weeds, by the proper use of the harrow and disc. The roller and cultipacker are generally used in packing and pulverizing the seed bed. Beans planted on late-plowed fields are likely to be more seriously affected by diseases and, during cultivation, are more difficult to keep free of weeds. In fitting the seed bed for beans, firm with the roller to break clods and fill air spaces, and after the roller use the harrow to save moisture. Disc and harrow at weekly intervals to kill weeds as they germinate. Early plowing and thorough fitting greatly lessen the labor and cost of later cultivation and effectively control the bean maggot, which often causes injury on newly plowed clover sod or newly manured land.

Fertilize Where Needed. Manure and mineral fertilizers are effective in increasing yields and cheapening costs per bushel in bean production. Manure should be applied, where possible, to the previous crop. From 6 to 8 tons of manure, supplemented by 200 or 300 pounds of superphosphate, usually pave the way for a big crop of beans at a low cost per bushel. Acid phosphate aids in hastening the maturity of the crop, and hence lessens danger from frost damage in the fall.

Complete commercial fertilizers of a 2–12–4 or a 2–16–6 formula are effective. They should be used at the rate of 200 to 300 pounds per acre, preferably applied broadcast before planting. Only a small amount, 50 to 75 pounds, should be drilled in the row with the seed beans. Acid soils should be limed, previous to planting with beans.

Plant on a Well-Warmed Seed Bed. The planting time for beans in the Lake States ranges from May 25 to June 25. About June 10 is the usual date in most of the bean districts. It is better to wait until the seed bed is well warmed and worked into an excellent condition of tilth, rather than to plant when cold or wet. Beans require almost ideal conditions for even germination. Every bean seed planted is pushed out of the ground, hence the need for a well-prepared seed bed. Unless the start is uniform, the harvested crop is not likely to be uniform in maturity, which means a higher pick and difficulty in curing and threshing.

The amount of seed used in planting an acre depends upon the variety. From 20 quarts to 3 pecks of ordinary pea beans and 5 or 6 pecks of kidney beans is the usual rate. An ordinary eleven-hole grain drill is commonly used in planting. Every fourth hole is left open, and the drill wheel is allowed to follow its own track on the return, thus planting three rows with each passage, 28 inches apart. A two-row corn planter, equipped with special bean plates and narrowed to plant 28-inch or 32-inch rows, may also be used in drilling beans. Special bean drills are available in bean-growing districts. Beans should be planted to a depth of 1 to 2 inches.

Give Shallow Cultivation, Frequently Repeated. The first cultivation should be given as soon as the plants are high enough to make it easy to follow the rows. This cultivation should go close to the plants and fairly deep. The next cultivation, coming within a week or ten days, should be further from the plants and not so deep. Later, cultivation should be shallow because the feeding roots of the bean plants come close to the surface. Cultivators, carrying numerous small or medium-sized shovels or blades, are most desirable for later

cultivations. The blade types of equipment, known as duckfeet, sweeps, and half sweeps, are particularly effective in weed control and are used often for the first cultivation. Four to six cultivations are necessary, as a rule. Beans should not be cultivated when wet with dew or rain, since at that time the bean diseases, blight, anthracnose, and mosaic, are most easily carried from plant to plant.

The rotary hoe is now being used effectively in cultivating beans. Beginning two or three days after planting, the beans are cultivated with the rotary hoe every four or six days until the plants bush out and leaves are clipped. One or two cultivations with the ordinary cultivators are then made. The use of the rotary hoe greatly reduces the cost of bean cultivation.

Harvest As Soon As Mature and Before Pods Split, and Thresh with "Beaner." The early method of harvesting was to pull the mature bean plants by hand, cure in stacks or piles in the field, and thresh with a flail. At present, the bean harvester is used, and greatly lessens the labor of bean pulling. This implement consists of a frame on wheels, carrying two heavy knives. These knives, or blades, slip along underground just beneath the surface, pulling and throwing together two rows of beans at a time.

The harvesting should be done when the plants are mature, but should not be delayed until the pods are too ripe because at this stage shattering is likely to occur. After being pulled, the beans are forked into piles or, if the field is free from straw or trash, a side-delivery rake may be used in windrowing. After several hours' drying, the crop should be forked into cocks, built high and small at the bottom to allow rapid curing. After a period of four to seven days in good drying weather, the crop should be stored under a roof or in a well-constructed stack. Threshing is done in the barn or stack, a special bean thresher being used. The bean thresher carries one cylinder operated at a low speed, and a second at a high speed. The first cylinder threshes overripe beans with a minimum of splitting. The second, or rapid, cylinder threshes immature pods much more effectively. An ordinary grain separator can be used in threshing beans by removing every other concave and regulating the speed of the cylinder. Bean straw is valuable roughage, particularly in sheep and cattle feeding, and should be carefully saved for feed.

The average yield per acre of beans in the leading eastern bean states is about 12 bushels. Yields of 18 to 20 bushels are considered good yields, but occasionally very high yields of 35 or more bushels are reported.

Grow Beans in Rotation. For continued success in production, the bean crop must be included in a good rotation. "Beans after beans" soon results in low yields, owing to the rapid decrease in organic matter and the increased injury from bean diseases and insects. A good clover sod is considered excellent preparation for the bean crop. Such a rotation as the following is well adapted to beans: first year, beans; second year, wheat, rye, barley, seeded to clover; third year, clover.

Corn or potatoes can be included either before or after beans in a four-year rotation such as the following: corn; beans; small grains; and clover. A longer, and hence more desirable, rotation can be secured by seeding timothy or alsike, or both, with the clover, allowing it to remain in meadow for two or more years. The following are suggested as strong rotations.

A. On a farm with little livestock: (1) corn; (2) oats; (3) clover; (4) beans; (5) wheat; (6) clover.

B. For combined stock and crop farming: (1) corn or beans; (2) oats, barley, or wheat; (3) red clover, alsike, and timothy (hay); (4) pasture.

C. Alfalfa rotation: Alfalfa three to six years, followed by corn, beans, oats, or barley, seeded to alfalfa.

CHAPTER XXV

OTHER LEGUMES

Numerous legume crops, in addition to those considered in previous chapters, have been found to be of particular importance in the farming programs of various sections of the United States.

Concise information about legumes for pasture purposes is to be found in Table 34. Alfalfa and sweet clover have been discussed in more detail in Chapter XXII, while the red alsike and white clovers have been considered in Chapter XXIII. Further information pertaining to some of the more important legumes constitutes this chapter. Table 34 furnishes detailed information concerning many legumes.

FIG. 127. One of the chief advantages of crimson clover, as compared to many other winter legumes, is its dependability in seed production. (*Kentucky Agricultural Extension Service.*)

Crimson Clover. Crimson clover, *Trifolium incarnatum,* the most important winter annual of the true clovers, was introduced into the United States in the early part of the nineteenth century. This species is self-fertile. The florets are not self-tripping; therefore maximum seed crops require insect visitation (177). Crimson clover

is an erect, pubescent, many-stemmed plant that may be particularly distinguished from other legumes by its long, numerous, compact heads of crimson-colored flowers (44).

Crimson clover seems to grow most successfully in the Atlantic areas south of New Jersey. It also does well in many places south of the Ohio River as far west as Kansas.

The composition of crimson clover as a feed is presented in Table 49 in the Appendix.

The Georgia Agricultural Extension Service (4) indicates that stubble land or other areas having considerable litter are well adapted to establishing stands of crimson clover. In that state the safest time to seed crimson clover south of the mountains is in September, after the first good rain. In mountain counties, August seeding is preferable. Seeding should be done at the rate of 15 to 20 pounds of clean seed or 40 to 50 pounds of seed in the chaff per acre. The seed bed should be loose on the surface and firm underneath. It is further suggested that the crop must be inoculated in order to secure good results and it is well to fertilize with 200 to 400 pounds of superphosphate unless the preceding crop was liberally fertilized with phosphorus.

The Tennessee Station (105) recommends that seeding be done on well-prepared land in July or August. Seeding in September may be successful, but the usual dry weather at that time is unfavorable. An October seeding is much more uncertain because the plants usually make insufficient early growth to survive the winter, except when sown along with a small grain or on grass or lespedeza stubble.

From 12 to 18 pounds per acre is the usual rate of seeding. The seed should be covered lightly. Good stands are the rule if there is ample moisture in the soil at seeding time. As is true of red clover, failure to take this matter into consideration often results in the loss of the stand before the fall rains come. Seed may be sown in a mixture with ryegrass, rye, or other cereal, on prepared land in September or early in October.

One of the chief advantages of crimson clover over many other winter legumes is its dependability in seed production and the comparative ease in producing a home supply of seed for planting. The methods used in seed production and harvest are well described in a publication of the Alabama Agricultural Extension Service (94).

According to this publication yields of 500 to 1000 pounds per acre of crimson-clover seed in the chaff usually may be secured. The seed may be harvested by using a homemade, hand-operated or horse-drawn stripper. Another method is to cut with a mowing machine,

TABLE 34 *

REGARDING LEGUMES FOR PERMANENT PASTURES

Name	Climatic Adaptation †	Degree of Palatability	Season for Grazing	Time and Rate of Seeding per Acre	Soil Adaptation	Remarks
Alfalfa (*Medicago sativa*)	all regions where moisture is sufficient, but only locally in Region 2	very high	spring to early fall. Winter grazing in Southwest, where irrigated	depending on location — consult state experiment station	practically any fertile soil type not wet nor acid	good pasture, but danger of bloat
Alsike clover (*Trifolium hybridum*)	chiefly Region 1 and section 5*a*. In sections 3*a* and 4*a* if moisture is sufficient. Winter crop Region 2	very high	early spring and fall	early spring; 8 to 10 pounds	practically any soil type, except sands. Will stand slight acidity	especially suited for wet land
Red clover (*Trifolium pratense*)	chiefly Region 1 and section 5*a*. In sections 3*a* and 4*a* if moisture is sufficient. Winter crop Region 2	very high	early spring to fall	early spring; 10 to 15 pounds	practically any well-drained soil if not acid	use locally adapted seed
Mammoth red clover (*Trifolium pratense var.*)	Region 1, chiefly section 1*a*	high	early spring to fall	early spring; 10 to 12 pounds	practically any well-drained soil, not more than slightly acid	will endure slightly more soil acidity than common red

White clover (*Trifolium repens*)	all regions where moisture is sufficient	very high	early spring and fall	very early spring; 5 to 10 pounds	practically any soil type	everywhere in the North. In Region 2, winter and spring crop †
Ladino clover (*Trifolium repens var.*)	sections 4*a*, 5*a*, and 5*b*	very high	spring to fall	early spring; 5 to 10 pounds	practically any well-drained, well-watered soil	Very productive but injured by heavy continuous grazing; danger of bloat
Least hop clover (*Trifolium dubium*)	sections 2*a* and 5*a* and parts of 1*b*	high	spring	late summer; 4 to 5 pounds	good soil	annual, disappears in June, volunteers
Low hop clover (*Trifolium procumbens*)	section 2*a* and southern part of section 1*b*	high	spring	late summer; 4 to 5 pounds	practically any well-drained soil	annual, usually disappears in June but volunteers
Sweet clover (*Melilotus alba* and *M. officianalis*)	Regions 1, 2, and 3, also section 4*a* where moisture is sufficient	medium	very early spring (2nd year) to late fall (1st year)	winter and very early spring; 15 to 20 pounds	any well-drained, non-acid soil	nutritious pasture, but its success often requires applications of lime
Strawberry clover (*Trifolium fragiferum*)	locally in sections 3*a*, 4*a*, and 5*a*	high	spring to fall	early spring; 5 to 10 pounds	wet alkali soil	grown only locally, domestic seed produced in Oregon
Sour clover or annual melilot (*Melitotus indica*)	Region 2 and sections 3*b*, 4*b*, and 5*b*	medium	winter and early spring	late summer	sweet well-drained soils	annual, volunteers; no value north of Region 2
Yellow trefoil or black medic (*Medicago lupulina*)	Region 2 and section 1*b*	very high	early spring to late fall	very early spring; 8 to 12 pounds	well-drained sweet soils	not prominent, except on black land in Alabama and Mississippi

* By H. N. Vinall and C. R. Enlow, United States Department of Agriculture.

† The region and section numbers refer to the map, page 308.

TABLE 34—*Continued*

REGARDING LEGUMES FOR PERMANENT PASTURES

Name	Climatic Adaptation †	Degree of Palatability	Season for Grazing	Time and Rate of Seeding per Acre	Soil Adaptation	Remarks
California bur clover (*Medicago hispida*)	sections *3b*, *4b*, and *5b*, if sufficient moisture, also eastern Texas and Oklahoma	high	fall to spring	late summer; 15 to 20 pounds; hulled seed	well-drained soils of practically any type	a winter annual. Volunteers
Southern bur clover (*Medicago arabica*)	Region 2 and section *3b*	high	fall to spring	late summer; 10 to 15 pounds; hulled seed	well-drained soil	winter annual, but reseeds
Common lespedeza (*Lespedeza striata*) ‡	Region 2 and section *1b*	high	early summer to fall	early spring; 20 to 25 pounds	well-drained soil	annual, but is usually permanent in pastures because of volunteer seeding
Korean lespedeza (*Lespedeza stipulacea*)	section *1b*	high	early summer to fall	early spring; 20 to 25 pounds	practically any well-drained soil	annual, but volunteers

† The region and section numbers refer to the map, page 308.

‡ Kobe and Tennessee 76 are heavy-yielding strains of common lespedeza which should be used in Region 2 and the southern part of section *1b*.

allowing the material to dry in the windrow and then storing for threshing. The publication suggests a simple method of threshing, namely, that of throwing the plants on large-mesh poultry wire, stretched over a wagon box or other receptacle, and beating the seed out with a pitch fork. Seed thus separated when intended for home use needs no further separation or cleaning.

Crimson clover makes an excellent hay crop. It should be cut in the early bloom stage and should be well cured. It is claimed that the hairy material from late-cut crimson clover tends to form "hair balls," in the alimentary tracts of horses and mules, which may cause the death of the animals. Crimson-clover hay is about equal to red-clover hay in protein content.

Lespedeza. *Lespedeza striata* is represented in the United States by the following annual varieties: common, Tennessee 76, and Kobe. Korean and Harbin are annual varieties of *L. stipulacea*. These annual types, according to an Illinois publication (117), are small-branched plants which grow either erect or spreading, to a height of 30 to 36 inches under good conditions, but more commonly attain a growth of 5 to 15 inches. The plants are characterized by many small, trifoliate leaves, inconspicuous purple flowers, and numerous medium-deep-growing fibrous roots. The seeds are dark purple in color and are borne singly in pods which are retained after threshing.

L. sericea is a perennial species which grows larger than the annual types. The plants resemble alfalfa to some extent but their small leaves, as compared to alfalfa and inconspicuous purple or yellow flowers, help to distinguish the crop.

Common lespedeza was introduced into the United States from Japan some time prior to 1846. The origin of the crop accounts for the name, Japan clover, which is used rather commonly. Tennessee 76 is a superior strain of the variety common selected at the Tennessee Station. Kobe lespedeza was introduced into South Carolina from Kobe, Japan, in the year 1919. In the same year, Korean was introduced from Korea, by the United States Department of Agriculture. The same organization brought the Harbin variety from Harbin, Manchuria, in the year 1929.

Lespedeza seems best adapted to the regions of southern Pennsylvania, Ohio, Indiana, and Illinois and to the states south of these areas. The region includes the easternmost parts of Kansas, Oklahoma, and Texas.

Some conception of the increase in the use of this crop may be gained from information concerning the harvested acres of lespedeza

seed. In the year 1925, the acreage harvested was 29,500; 1930, 55,500; 1935, 370,300; and in 1938, 703,000 acres.

From experiences at the Tennessee Station (105), it has been stated that the annual lespedezas will grow almost anywhere if adapted but that they respond very well to liming and to the use of phosphorus and potassium if the soils are deficient in these elements. Results indicate that late February and early March seedings are best in Tennessee. It is recommended that 25 pounds of seed per acre be

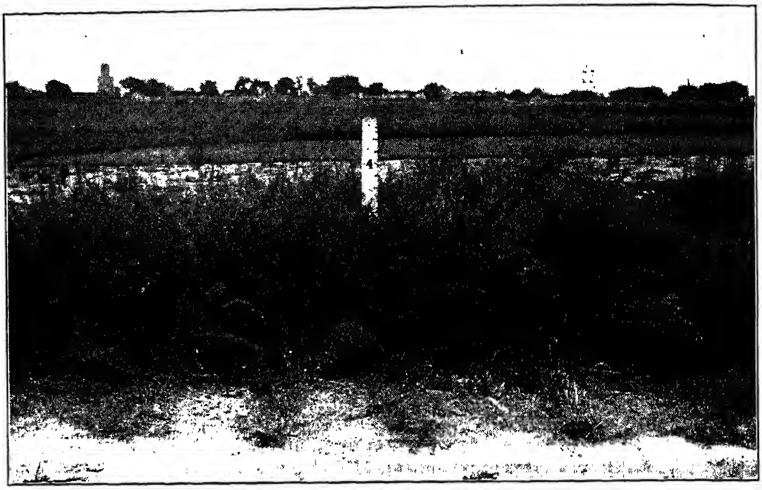


FIG. 128. *Lespedeza sericea* is a perennial species of lespedeza introduced from Japan in 1925. (*Illinois Agricultural Experiment Station.*)

used to secure a full stand for all varieties except Kobe, for which 50 pounds of seed per acre is necessary because of the large size of the seed. When the seed bed has been prepared recently or when there is a loose soil mulch, it is unnecessary to cover the seed. In any event it is important to avoid deep covering of lespedeza seed.

The growing popularity of lespedeza, as presented in an Illinois Station publication (118), is attributed to its value as a hay and pasture crop, its relative acid tolerance, its drought resistance, its relative freedom from insect and disease pests, and its low cost of seeding. Furthermore its growth habits and other characteristics give lespedeza special value as a soil-improving crop. It may serve as a green-manuring crop and it provides good protection against soil erosion.

From experiences with *L. sericea,* the perennial type of lespedeza, at the Tennessee Station (105), it may be concluded that it has about

the same adaptability to soils as the common annual lespedezas. Under Tennessee conditions it is recommended that seedings with unscarified seed be made in January, while late February and early March seedings should be made when using scarified seed. Scarified seed may be used at the rate of about 15 pounds per acre, whereas 25 or more pounds of unscarified seed has been found necessary to secure a stand. No special covering of seed is advised for either the winter or early spring seedings. Harrowing before seeding is suggested if the surface of the soil is crusted or compact. At the Tennessee Station winter or early spring seedings on wheat or other small grains have given especially good results.

The first-year stands of perennial lespedeza are inclined to be light but the second-year growth is much more vigorous while even further improvement in stand may be expected in the third year if conditions are reasonably satisfactory.

Under Tennessee conditions the first cutting of hay may be made in May, a second cutting in July, and a third cutting, depending upon growth, in October. A stubble of 2 or 3 inches needs to be left when mowing because the new growth develops from the old stems rather than from a crown. The crop is cut for hay when it is 15 to 18 inches in height.

Experiments show that a seed crop of 200 to 500 pounds per acre may be secured from *sericea* when planted in rows and cultivated. The usual practice is to cut the first crop for hay and use the second crop as the seed crop. Since the crop shatters easily it should be mowed when damp and handled carefully to avoid large losses of seed. The combine handles the crop very well and appears to be the best method to use in harvesting seed.

Austrian Winter Peas. Austrian winter pea (*Pisum sativim*) seed was brought into the United States from Central Europe. The first planting in the Pacific Northwest, where most of the seed is now grown, was made at the Oregon Agricultural Experiment Station, in the year 1923 (141).

As described by the Oregon Station, the Austrian winter pea, when planted in the fall, passes through a definite period of winter dormancy before spring growth begins. The stems grow to a length of 3 feet, are smooth, and light green in color. The leaves are smaller than those of the garden and spring varieties of field peas. The plants are trailing or decumbent.

The value of Austrian winter peas is demonstrated by the facts found in Table 35, from results of investigations at the Coastal Plain Experiment Station, Tifton, Georgia (3).

TABLE 35

CORN AND COTTON FOLLOWING SOIL-IMPROVEMENT CROPS

Crops	Bushels Corn per Acre (12-Year Average)		Pounds Seed Cotton per Acre (12-Year Average)	
	10-0-4 fertilizer	10-2-4 fertilizer	9-0-5 fertilizer	9-3-5 fertilizer
Austrian winter peas	50.3	47.6	1351	1333
Monantha vetch	45.8	48.6	1286	1474
Hairy vetch	45.7	47.8	1266	1424
Rye	30.6	34.4	1079	1290
None	31.2	33.9	772	1010

Under Oregon conditions (141), it has been found that plowing and subsequent preparation of the seed bed provide the best soil preparation for Austrian winter peas. Fall seedings, made before November 1, are the most successful in western Oregon. Spring seedings are often made in the coastal sections. On lands adapted to peas, 75 pounds of peas are used when seeded alone and, when seeded with small grain, at least 60 pounds are used with 3 to 5 pecks of grain. It is very important to inoculate the seed if the peas are to be grown on land which has not previously been used for this crop. Drilling seems to be the best method of planting. Applications of gypsum are essential on those soils which show beneficial results from gypsum applications on vetches, clover, or alfalfa. In the Northwest, Austrian winter peas are used as a seed crop, soiling crop, and for pasture, silage, and hay.

Under southern conditions, Austrian winter peas are used primarily as a soil-improving crop. In Georgia (3), using that state as an example, this crop is seeded the latter part of September or the first part of October. When sown alone for soil improvement, 30 to 40 pounds of seed are used. When sown with small grains for hay, 15 to 20 pounds of seed are used. Inoculation is essential. If sown on land where no phosphorus has been used with preceding crops, 200 to 400 pounds of superphosphate or its equivalent should be applied. On poor soils some manure is beneficial and, when in combination with small grain on poor to fair soils, 200 to 300 pounds per acre of a good cotton fertilizer is recommended.

A three-row drill with special seed attachments is recommended for planting Austrian field peas between the rows of standing crops. If the land is open, a regular drill may be employed. It is important to plant seed which has been inoculated so that the seed will be covered quickly enough to prevent the loss of the inoculating material. A common method of seeding is to broadcast and to cover the seed by cultivating in some manner. This method often results in a waste of seed and poor inoculation.

As a soil-improving crop, Austrian winter peas are turned under or disced in, two to three weeks ahead of the time of planting summer crops. When sown with small grain this crop gives excellent winter and spring pasture or may be used for hay.

In a publication of the Virginia Agricultural Extension Service (55), the recommendations relating to Austrian winter peas call for seeding rates of 60 pounds when sown alone for soil improvement, and 40 pounds of peas and 40 pounds of oats when planted for hay purposes. Fall or spring seedings may be made and 200 to 300 pounds of 0–14–6 fertilizer recommended to meet fertility needs.

Field Peas. The field pea, *Pisum arvense,* is an annual plant of the legume family. It produces slender hollow stems 1½ to 6 feet in length. It makes a prostrate growth unless planted with a crop which supports it. The leaves and stem are pale green in color with a whitish bloom on the surface. The leaves are compound, bearing one or more pairs of leaflets and one or more pairs of tendrils. The flowers which are borne two or three to a stalk may be pink, white, or reddish purple in color.

The field pea is native to the Mediterranean region and western Asia, extending into the area of the Himalaya Mountains. The crop was introduced into this country in early colonial days. In North America it is particularly adapted to Canada, the Northern States and the regions of high altitude to the south in the Rocky Mountains.

In the South, field peas are planted in the fall as a winter crop. In the North, it is important to plant peas as early in the spring as the land can be prepared since cool weather during the growing season is essential.

The rate of seeding depends upon the size of the seed which differs according to varieties. From 1½ to 3½ bushels of seed per acre may be required. Although the crop may be drilled or broadcast, drilling is considered preferable. Field peas are often planted in combination with oats for pasture or hay purposes. The seeding rate is commonly 1½ bushels of peas and 1½ bushels of oats.

Field peas should be cut for hay as soon as the pods are well formed. Because the crop ripens unevenly, peas should be cut for grain when most of the seed can be saved.

In addition to being used for hay and grain, field peas are utilized for pasture, green-manuring, and cover-crop purposes.

Cowpeas. The cowpea is of particular importance in the South, though adapted varieties are grown to a considerable extent in the southern part of the Corn Belt. It is a warm-weather crop, very susceptible to frost. It is indeterminate in its growth, producing flowers and mature beans until growth is stopped by frost. The cowpea is well established where adapted as a valuable soil-improving legume and as an excellent forage crop for hay and pasture. The seed of cowpeas furnishes valuable feed for livestock and some varieties, particularly the Black-Eye, are used extensively for human consumption.

The leading varieties of cowpeas grown for forage and soil improvement are the Whippoorwill, Iron, New Era, and hybrids of these varieties, the Groit and Brabham. The Black-Eye variety is used for forage, soil improvement, and as a table variety.

Cowpeas are usually planted in rows 3 feet apart with seed every 2 or 3 inches, using 40 pounds an acre, or they may be drilled solid at rates of a bushel or a bushel and one-half per acre (60 to 90 pounds). Plantings should begin when the ground is well warmed up, in May or early June. When planted for seed, cowpeas are usually grown in rows and given thorough cultivation. Seed yields usually average 4 or 5 bushels per acre. When grown for hay, they are usually drilled solid. Cowpeas are frequently planted at the time of the last cultivation of corn, a bushel or a bushel and one-half per acre being broadcasted.

Owing to the succulence of the vines, cowpeas are more difficult to cure for hay than soybeans. They should be cut with the mowing machine when the pods begin to turn yellow. After wilting in the swath, the hay is raked into windrows and allowed to cure for one or two days. The hay is then forked into high, narrow cocks, usually around frames built for the purpose. The hay is considered equal to red-clover hay if properly cured.

Hairy Vetch.—*Vicia villosa,* or hairy vetch, is a viny legume with purple flowers. It is a winter annual when seeded in the fall, and a biennial when seeded in the spring. This vetch is cold-resistant, and adapted to cool, temperate climates. It is rather tolerant of soil acidity and it has good soil-building and soil-conserving qualities.

There is some objection to its viny and prostrate habit of growth, to the seed cost per acre, and to the fact that it often becomes a weed in grain fields.

The rate of seeding when sown alone varies from 40 to 60 pounds per acre. It is usually planted with small grain. The vetch is seeded at the rate of 20 to 30 pounds per acre while the small grain is seeded at the usual rate.

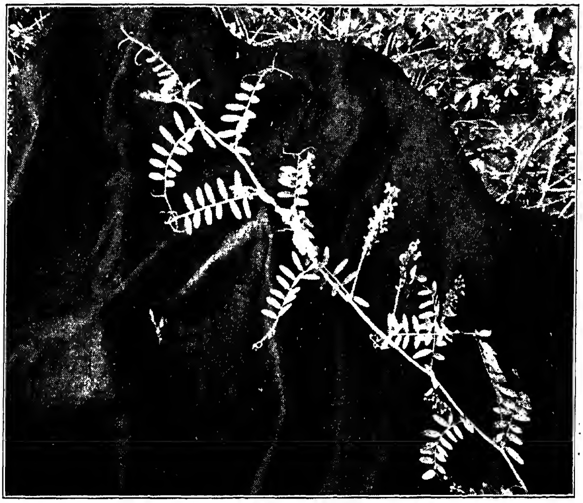


FIG. 129. Hairy vetch is cold-resistant and adapted to cool, temperate climates. (*Kentucky Agricultural Extension Service.*)

Hairy vetch is useful as a green manure, hay, pasture, or silage crop.

Common Vetch. *V. sativa,* or common vetch, is an annual legume which, according to an Oregon Station publication (143), may be used for hay, seed, soiling, pasture, silage, green manure, cover crop, or a crop for honey production.

Common vetch is similar in nature to the hairy vetch but is less hardy. It is best suited to a moist, cool, climate, free from extremes of heat or cold during the growing season.

From 60 to 80 pounds of seed are planted per acre. Common vetch is usually planted with a grain crop such as rye or oats.

Monantha Vetch. Monantha vetch, *V. monantha,* is similar to other vetches in its habits of growth. This vetch is adapted to such regions as Florida, southern Georgia, southern Alabama, and other

similar regions. It cannot be grown safely even in the northern portions of the Cotton Belt.

Bur Clover. Bur clovers are annual legumes having small, yellow flowers. The seed is borne in tightly coiled, spiny pods or burs. The bur clovers are of importance in the Cotton Belt, in California, and in western Oregon and Washington. They are of particular value in furnishing good winter and spring pasturage for cattle, sheep, and hogs. They grow best on moist, well-drained, fertile soils. Poor soils should be fertilized with several hundred pounds of fertilizer high in phosphorus. Plantings are made in late summer or fall at the rate of 15 pounds of seed per acre, drilled or broadcasted. The crop is seldom harvested for hay purposes, owing to light yields secured.

Velvet Beans. Velvet beans have gained rapidly throughout the Coastal Plains region of the South, and are considered one of the most valuable legumes for use in soil improvement. From 15 to 25 pounds of seed per acre are required when planting with corn or millet, and 40 to 60 pounds when planted alone. Owing to the vigorous growth made by this crop, it is desirable to plant with corn, millet, or another crop that will hold up the vines when the seed is to be harvested. The crop is a heavy seed producer, producing 20 to 30 bushels of seed per acre. It is considered an excellent fall and early winter pasture crop for cattle. Velvet beans are planted in the spring, 15 to 20 pounds per acre being used.

Kudzu. Kudzu is a valuable soil-improving and forage crop adapted to the Southeast. It is a perennial leguminous vine brought to this country from Japan. Owing to its vigorous root system and vine growth, kudzu is particularly useful in stopping erosion in gullies and on steep hillsides. The crop may be grazed or harvested for hay. Its growth becomes woody in regions where not killed to the ground by frost.

Kudzu is established by setting out rooted plants two years old or older. The plants are usually set $3\frac{1}{2}$ by $3\frac{1}{2}$ feet but the cost of planting can be reduced by spacing the plants every $3\frac{1}{2}$ feet in rows 7 feet apart, and growing a row of corn or other cultivated crop between two rows of kudzu the first season. About 1800 plants are required per acre if spaced $3\frac{1}{2}$ by 7 feet. The plants should be cultivated for the first and often for the second year to control weeds.

When established, a field of kudzu will provide hay and pasture for many years. It is conceded that where alfalfa, clover, or lespedeza can be grown, kudzu has little place in the cropping program.

However, on poor soil, very steep soils, and on the sides of gullies, this crop is a valuable one. It is not adapted to planting farther north than Washington, D. C. Its chief place is on submarginal land particularly where moisture is often deficient, in the South or Southeast. Dr. A. J. Pieters, of the Bureau of Plant Industry, Washington, D. C., suggests that the southern farmer should plant a small area to kudzu, to be expanded if the crop proves profitable. He can dig his own roots and extend the plantings at a minimum of cost.

Crotalaria. This vigorous, summer-growing legume is of considerable importance in Florida as a green-manuring crop and is adapted, in general, to most of the Cotton Belt in regions of ample rainfall. *Crotalaria striata* is a wider-stemmed, taller-growing species. The plants often reach a height of 4 or 5 feet. It is considered better adapted to dry, sandy soil. The seed of *C. striata* is brown or olive green in color. *C. spectabilis* is finer stemmed; the seed is black in color. Both species are killed by temperatures of 28 degrees Fahrenheit, or lower. Strains of crotalaria that are palatiable for livestock have not, as yet, been developed. The seed is planted from April to June for well-fitted seed beds, using 20 pounds of seed per acre, either broadcast or planted in rows. The seed should be scarified before planting. The planting season ranges from April to June. Inoculation apparently is not necessary since natural inoculation occurs throughout the Cotton Belt. Crotalaria is remarkable as a crop that will produce an abundance of organic matter and that will greatly increase the nitrogen in the soil. If turned under at a succulent state of growth, decomposition and incorporation with the soil takes place rapidly.

Sour Clover or Annual Melilot. This is an annual legume which, like lespedeza, reseeds in pastures each year and thus becomes more or less permanent. It is very sensitive to soil acidity, and therefore is found growing only on soils of limestone origin or those but slightly acid. Its distribution is confined to our southernmost states, and it is of no value in the North.

Strawberry Clover. This is a perennial legume with about the same habit of growth as white Dutch clover. It is reported to be where it apparently thrives on excessively wet soils and yet is able to resist drought. Here in the United States it is grown only locally in sections of the Western States, and so far has not proved useful in the humid Eastern States. Its chief recommendation is its ability to grow on alkali soils.

Peanuts. The peanut, *Arachis hypogoea,* is an annual plant with a tap root. The stems are hairy, branching, angular and rather thick. The leaves are compound. Orange-yellow flowers are borne in the axils of the leaves. The plants bear both sterile and fertile flowers. Most of the sterile flowers are found in the upper axils. When the ovules are fertilized, the flower stalk lengthens, bends toward the soil, and, if normal growth is completed, the developing ovary is carried several inches into the ground. Ovaries which do not enter the soil do not mature.

The varieties grown in America may be classified as large podded or as small podded. Each of these forms may be further classified as "bush" or "bunch" peanuts or as the "running" type.

Varieties of the large-podded running type are the Virginia Runner, North Carolina Running, and African. Virginia Bunch and Jumbo are large-podded peanuts of the bush type. Spanish, Valencia, Tennessee White, Tennessee Red, and Georgia Red are varieties of the small-podded bunch type.

Peanuts should follow a clean-cultivated crop in order to avoid difficulty with weeds. The seed bed needs early and thorough preparation. In the Gulf Coast States planting may begin about the middle of April. As far north as Arkansas, if early varieties are used, the date of planting may extend to the middle of June.

Bunch-type peanuts may be planted in rows about 30 to 40 inches apart, with hills 6 inches apart in the rows. Rows 36 to 40 inches apart and hills 8 to 10 inches apart in the row are suitable for the running type of peanuts. From 25 to 35 pounds of shelled nuts of the small-podded, bunch type are needed to seed an acre. Larger seeded varieties will require from 30 to 40 pounds of seed per acre. If unshelled nuts are used for planting it is suggested that the large pods be broken in two and that the pounds of seed per acre be increased about one-third over the amount used for shelled nuts.

Cultivation is essential in the control of weeds and in providing loose soil about the plants when the pods are "pegging down."

Peanuts are ready for harvest when the veins on the inside of the pods are darkened and when the leaves of the plants have yellowed. Harvesting is accomplished by implements which loosen the soil about the plants. For large areas, potato diggers or beet lifters may be used.

Peanuts are cured by stacking them on or about poles which have cross arms placed 10 to 12 inches above the soil. The plants are stacked with the nuts next to the pole. The vines hang outward and downward, thus carrying rain away from the center.

Much of the crop is hand picked from the vines after curing, but machines available for this purpose are used in areas where peanuts are produced on a commercial basis.

Georgia, Alabama, Florida, Texas, North Carolina, and Virginia are the states in which the production of peanuts is the greatest. In the year 1937, the total acreage of peanuts in the United States was 2,561,000 acres. Of this acreage, 1,653,000 acres were harvested for nuts, and the yield amounted to 1,320,675,000 pounds.

The peanut vines are used for forage while the nuts are used for animal and human food or for oil.

Research with Peanuts. The following information, taken from Senate Document 65 (130), pertains to research with peanuts.

Present Research

Research is being done on peanuts in a number of places, especially on breeding, as a legume in crop rotation, and on general problems; but there is need for further extensive research work. In the South, where oil has been pressed from cottonseed for more than half a century, it is natural that equipment and methods of processing and utilization developed for cottonseed are being used and adapted to peanuts and peanut oil. The increase in the amount of peanuts crushed for oil in the past two years, however, has focused attention on methods specifically adapted to this crop. The following research projects are in progress:

Agricultural Research

1. Genetic and agronomic investigations for the improvement of peanut varieties and their regional adaptation and place in crop rotation, especially with respect to their utilization for food, feed, and industrial purposes.
2. Studies of diseases and insect pests and methods for their control or elimination.
3. The investigation of the efficiency and nutritive value of the peanut and of peanut products as feeds for poultry and livestock, including the effects of peanuts and peanut products on the quality of pork, beef, poultry, eggs, and other products, as well as the general effect upon the health of the animals.
4. A study of possible methods of improving the flavor of peanuts and derived products.
5. Analysis of factors affecting the price of peanuts and investigation of the competition and interchangeability of other fats and oils with peanut oil.

Utilization

6. A study of methods for improving the quality and nutritive value of margarine made from peanut oil.
7. Investigation of methods of clarification and reuse of peanut oil used in frying potato chips.
8. Utilization of peanuts and peanut byproducts, especially for the production of industrial raw materials.

9. Studies of peanuts and peanut products in relation to pellagra in certain restricted human diets.

Berseem Clover. Berseem clover, otherwise known as Alexandrian or Egyptian clover, is an erect, annual, winter-growing plant with white, oval flower heads and rather narrow leaflets. It is usually killed by temperatures dropping below 20 degrees Fahrenheit. It is unsuited for acid soils.

Beggarweed. Beggarweed is a legume which is sometimes called Florida clover. It will grow on thin sandy land and is used for hay, grazing, and as a bird food. It is seeded by drilling 5 to 8 pounds of seed, or by broadcasting 10 to 18 pounds, at about the same time of year as cotton is planted.

Black Medic. Black medic, *Medicago lupulina,* is also known as yellow trefoil. It is an early spring legume, the seed of which germinates in both fall and spring. It resembles hop clover but is coarser, more vigorous, and longer lived. Black medic has a high lime requirement and is grown largely in the Black Belt section of Alabama. Inoculation is necessary. It is seeded at the rate of 15 to 20 pounds per acre for a full stand. Other pasture crops should be established before sowing Black Medic because its vigorous growth where phosphate is applied crowds out other pasture plants.

Lathyrus hirsutus. This plant is sometimes called wild winter pea. It has been planted by a few growers in the Black Belt of Alabama for a number of years. It slightly resembles Austrian peas but the seeds are small and rough. It furnishes excellent grazing in late winter or spring and it is used for hay and soil-building purposes also. Wild winter pea is seeded by broadcasting 25 to 30 pounds of seed per acre from September 1 to the end of October. This crop has succeeded on the heavier soils in the Black Belt area, but little experience has been had with it in other areas. Its fertilizer requirements are about the same as for Austrian peas or vetch.

Lupines. The lupine is the most important green-manuring, leguminous crop in Europe. Among the countless species and varieties, some are annuals while others are perennials. Only three are important in green manuring. These are all annuals and are the white, blue, and yellow lupines.

Lupinus augustifolius or blue lupine is a narrow-leafed lupine with blue flowers and leaves with seven to nine narrow leaflets. The lu-

pines with their strong root systems may grow to a height of four feet, and they flourish on sour, sandy soils. The crop may be injured by too heavy applications of lime. Extensive trials with lupines are being made by the Soil Conservation Service in the southern part of Alabama and in Florida.

CHAPTER XXVI

COTTON

Cotton is the great cash crop of the Southern States. With the increasing competition in cotton production and cotton marketing and with the increasing problems relative to its growth, it is important to give comprehensive consideration to the factors and practices relating to efficiency in cotton production.

Climatic and Soil Factors in Cotton Production. The map (Fig. 134) reveals the rather sharply defined limits of the cotton production areas in the United States. Frost-free seasons of about two hundred days and summer temperatures, averaging about 77 degrees Fahrenheit, characterize the northern limits. The southern limits extend to the point where autumnal rains, averaging more than 11 inches, damage the quality of the lint and interfere with picking except in a few areas where cotton may be grown under irrigation. The western boundary is largely set by the line of 20 inches of rainfall.

Soils that are well supplied with humus, have good moisture-holding capacity, and are drained and aerated well are the most suitable for cotton production. The soil acidity may range in *p*H from 5.2 to 7. East of the Mississippi lowlands, the soils require applications of nitrogen, phosphorus, and potash in order to produce satisfactory crops. In the drier, western areas of the Cotton Belt, less fertilization is required.

Cotton production on some of the best cotton-producing soils has been curtailed because, although the growing conditions are favorable and result in high quality, an accompanying retardation of maturity results in severe damage from boll weevil infestations. Cotton production has been extended to some of the lighter soils with resulting earlier maturity and escape from serious weevil injury.

Cotton in Rotation. Cotton production is often associated with soil erosion and fertility depletion. This is true because the land used for the crop is very frequently used continuously for cotton or other cultivated crops. Certain economic factors pertaining to commercial agriculture often have made it unprofitable to use soil- and fertility-

conserving practices. Suitable crop rotations have been suggested but their adoption has been rather slow.

A suitable rotation for cotton might be as follows: first year, cotton; second year, summer legumes for hay or seed, followed by winter legumes; third year, corn interplanted with cowpeas, soybeans, or velvet beans.

Another rotation has been suggested as follows: first year, cotton, followed in part by a winter legume; second year, cotton; third year, summer legumes for hay or seed, followed by winter legumes; fourth year, corn, interplanted with summer legumes.

FIG. 130. On north Georgia clay soil an unfertilized plot (left) produced 31 pounds of seed cotton. A plot of similar size (center) produced 100 pounds of seed cotton when a complete fertilizer was used, while a plot (right) that received a fertilizer lacking one of the major elements produced but 49 pounds of seed cotton. (*Georgia Agricultural Extension Service.*)

Fertilizing Cotton. From 200 to 400 pounds of one of the following grades of fertilizer, 4–8–4, 3–8–3, 3–8–5, or 6–8–4, are commonly used in growing cotton. Although these applications are used most generally, it is recommended frequently that heavier applications be used. The Georgia Agricultural Extension Service (185) suggests that the best fertilizer for cotton on average Georgia soils is a 4–8–6 mixture, applied at the rate of 400 to 600 pounds per acre, plus a side dressing of 75 to 100 pounds of nitrate of soda.

The Alabama Agricultural Extension Service (93) suggests the general use of 600 pounds per acre of a 6–8–4 fertilizer or its equivalent. The South Carolina Agricultural Extension Service (122) suggests the use of 400 to 600 pounds of 8–4–6, plus 100 pounds of 16 per cent sodium nitrate or its equivalent, the latter to be used as a side dressing after chopping.

Fertilizer-placement experiments, conducted throughout the Cotton Belt from North Carolina to Texas, as reported in the 1938 Yearbook of Agriculture (178), indicated that fertilizer, applied to cot-

ton at planting time, gave best results when placed in bands located in a zone $1\frac{1}{2}$ to $3\frac{1}{2}$ inches to each side and 1 to 3 inches below the level of the seed. A comparison of various methods of applying fertilizer to cotton is presented in Table 36.

TABLE 36

YIELD FROM SIDE PLACEMENT COMPARED WITH THAT FROM OTHER METHODS OF APPLYING FERTILIZER TO COTTON *

Methods of Application (600 Pounds 6–8–4 per acre)	Yield per Acre	Increase
	(Pounds)	(Pounds)
No fertilizer	638	
Bands 2 inches under seed, at planting †	787	149
Bands, 3 inches under seed, 10 days before planting †	971	333
Mixed with soil under seed, before planting †	1073	435
Bands 3 inches each side, 3 inches below seed level, at planting	1191	553
Bands $2\frac{1}{2}$ inches each side, 3 inches under seed, 10 days before planting	1275	637

* Results are averages for experiments at four locations in 1936. Yearbook of Agriculture, 1938.
† Common farm practice.

The turning under of legumes has a marked effect in increasing yields of cotton. It is reported in the 1938 Yearbook of Agriculture (178), that, in Alabama, increased yields of cotton after cowpeas and vetch were cumulative, being greater in the second ten-year period than in the first. In the third period, yields increased to 116.62 per cent on the vetch area and to 198.28 per cent on the cowpea-vetch area over the yield from continuous cotton. In Georgia and in Louisiana, increases in cotton yields, after the turning under of legumes, ranged in round numbers from 22 to 100 per cent in various experiments.

When good legume crops are turned under in cotton production, the amounts and quality of the fertilizer used are changed. The Alabama Station (93) suggests that, when a good crop of winter legumes has been plowed under, 300 pounds of superphosphate and 48 pounds of nuriate of potash be used per acre.

Results from the Delta Branch Experiment Station, Stoneville, Mississippi, indicate the amount of nitrogen added to the soil with the turning under of winter legumes. An average in pounds per acre per year for the period 1933 to 1938 for various legumes is as follows: Austrian winter peas, 69.1; hairy vetch, 82.9; *Melilotus indica*, 54.6; California bur clover, 109.9.

Varieties and Seed Quality. It is generally recommended that varieties having a staple length of 1 to $1\frac{1}{32}$ inches be used. Wilt-resistant varieties should be selected for lands containing the organisms that cause wilt. The recommended varieties are to be found in Table 51 of the Appendix.

The quality of seed is a very important factor. It is recommended by the South Carolina Agricultural Extension Service (122) that seed stock be renewed yearly by securing sufficient seed from the breeder to grow enough seed for the succeeding year. It is urged that only seed of known origin, free from mixture, and of known germination be used. It is further suggested that seed for planting be saved from seed cotton that is disease-free and undamaged by weather. It is also recommended that cotton seed be treated with mercury dust compounds previous to planting and that the seed be delinted.

Efforts have been made to establish what is known as One-Variety Cotton Communities. According to an Arkansas publication (125), the one-variety community plan of cotton production has been developed with the object of producing fiber of uniform quality to be made available to the trade in quantities sufficient to establish a community reputation for quality cotton. Cotton cross-pollinates to a great extent, and a large amount of seed mixing occurs in the ginning process. It is very difficult, therefore, to keep a number of varieties within one community in a pure state. Crossing and mixing causes the so-called "running out" of cotton seed.

Seed-Bed Preparation for Cotton. Land to be used for cotton production is plowed in late winter or very early spring in some sections. In other areas, the plowing may be done in the fall or winter. It is essential to plow very thoroughly and to cover old cotton stalks or other vegetative matter that may be on the land.

About ten days or two weeks before cotton-planting time, rows are marked off, ranging from $2\frac{1}{2}$ to $4\frac{1}{2}$ feet in width. On good lands the rows are wider, but on poorer soils the narrower widths are used. The rows are then "bedded," which means that a low ridge is made over each row. This is accomplished by the use of turn plows or by cultivators equipped with disc or turn-plow attachments. The seed bed is then allowed to settle for about ten days, as previously indicated. Just before planting, the rows are harrowed in order that the seed may be placed in freshly cultivated soil.

Planting and Cultivating Cotton. Cotton planting should be delayed until at least two weeks after the last killing frosts may be ex-

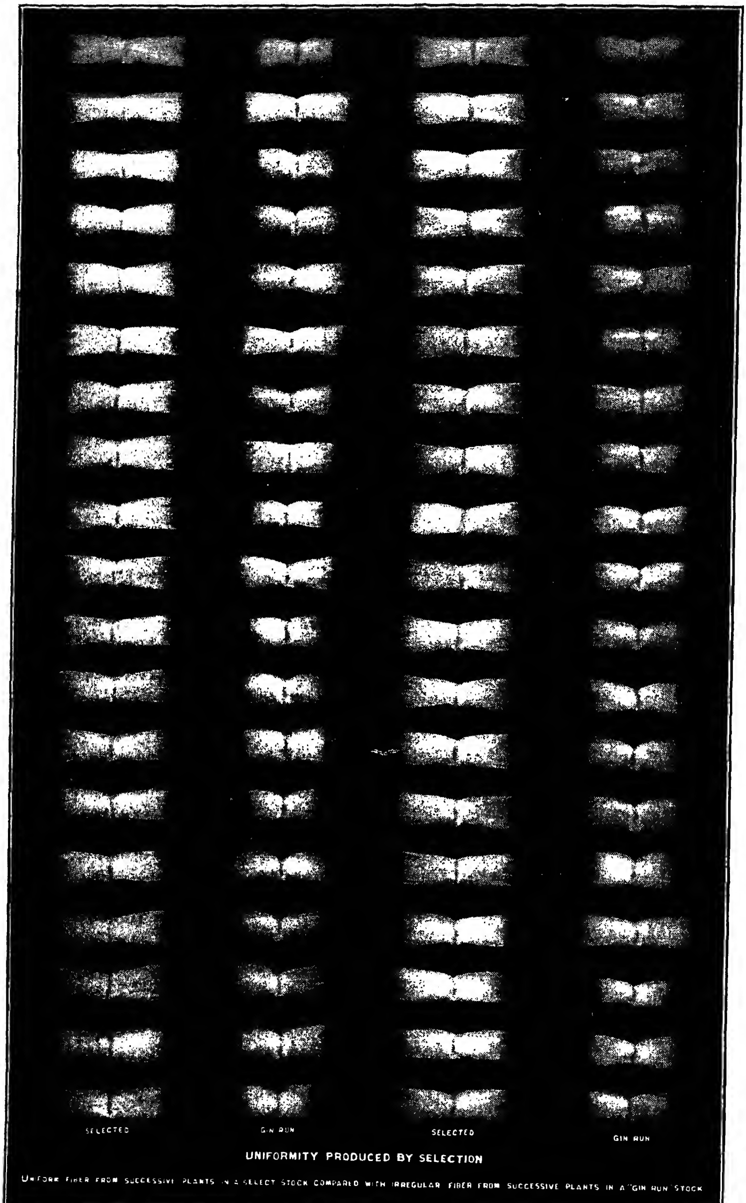


FIG. 131. The samples illustrating uniformity in length of staple were produced from a purebreed, selected variety of cotton. The samples illustrating lack of uniformity were produced from unselected or "gin-run" seed. (*Georgia Agricultural Extension Service.*)

pected. The soil must be warm enough to promote rapid germination because cotton seed rots very easily in soil which is too cold.

About 1 bushel of seed per acre will be needed if a continuous-drill type of planter is used, while a hill-dropper type will require about ½ bushel of seed per acre. The amount of seed may vary from ½ bushel to 1½ bushels, depending upon the width of rows, germination, and other factors.

FIG. 132. Cotton is planted on low ridges or "beds" in order to secure adequate drainage. (*Georgia Agricultural Extension Service.*)

Cotton is commonly planted about 1 inch deep. The exact depth, however, must be regulated according to soil conditions. Some investigations are being conducted with variable-depth planters which put the seeds in continuous-drill rows; but, within a short distance, seeds are planted at different levels, it being assumed that at least one of the depths will fulfil the requirements for securing a stand.

When plenty of seed is used, the germinating seeds together have the strength to break through soil crusts which may develop.

When the continuous-drill type of planter has been used, the first cultivation may be made with a weeder or spike-tooth harrow across the rows. Another form of first cultivation, sometimes called *barring off*, consists in running a scraper close to the plants, throwing the dirt away from them. These procedures are followed by hoeing and *chopping*. The latter term refers to the process of cutting out plants to leave the desired stand. Hills 12 to 18 inches apart, containing one to three stalks, often represent the type of spacing used. The distance left between plants or hills depends upon soil conditions. Wide spac-

ing in the row is used with good soils, and narrow spacing with poor soils.

Cotton is cultivated with the purposes of preventing the growth of weeds and grasses, of providing a surface mulch of loose soil, and of maintaining low ridges on which the plants may grow and be kept out of water.

Cotton Picking and Ginning. Cotton picking begins in September and often continues into December because not all the bolls on a particular plant ripen at once. Pickers go over the fields a number of times. From 150 to 250 pounds of seed cotton may be gathered in a day by an average picker. Machine pickers have been used to some extent, but as yet practically all cotton is picked by hand.

It is important to pick cotton frequently in order to avoid weather damage. Only wide-open, fully matured, dry bolls should be picked. Picking should be done so that dirt, trash, and other foreign matter is prevented from becoming mixed with the cotton.

Seed cotton is frequently hauled to gins as soon as it is picked or immediately thereafter. Only mature, dry cotton should be ginned. The ginning process separates the lint from the seeds. The lint is baled after the removal of the seeds. As previously stated, about 1500 pounds of seed cotton are required to yield a 500-pound bale of lint. A bale of cotton usually consists of 478 pounds of cotton and 22 pounds of bagging and fasteners.

Often the bales of cotton are sold immediately after the ginning process. If not, it is very important to store the bales in a dry place. Cotton seed needs to be stored carefully to prevent heating.

Cotton Insects and Diseases. A number of insects and diseases reduces the profits of cotton production.

Boll Weevil. It is stated that the Mexican boll weevil entered the United States from Mexico, in the year 1892. The insect spreads rapidly and has caused great damage to the cotton crop every year since that time.

As soon as cotton plants emerge in the spring after planting, they are attacked by adult boll weevils which have lived through the winter. The beetles continue feeding on the tender parts of the foliage until the squares or embryo flowers are formed. At this time the female beetles lay their eggs in the square. The eggs hatch in about three days. The larvae feed for about ten or twelve days, pupate and remain in this stage from three to five days, and then emerge as beetles ready to repeat the process of reproduction in about five days. Not only a great destruction of squares takes place but the boll form of the crop is also attacked.

Some control of the weevil is obtained through applications of calcium arsenate to the plants before squares are formed. The poison may be dusted on the plants or applied by mopping the plants with a mixture of calcium arsenate, syrup, and water.

Later applications of dust or spray are useful in controlling this insect.

It is recommended that cotton stalks be destroyed as soon as the cotton is picked as a means of reducing the weevil infestation the following spring.

Cutworms. Numerous types of cutworms feed on the cotton plant, consuming the leaves and cutting down plants. Various poison

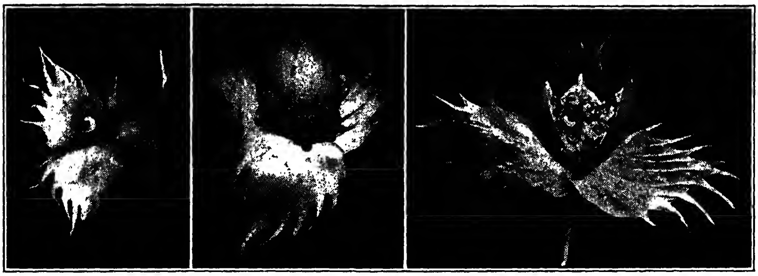


FIG. 133. A cotton square and cotton bolls infested with the cotton boll weevil. (*Georgia Agricultural Extension Service.*)

mashes made from wheat bran, white arsenic, sodium arsenate, or Paris green, moistened with molasses or syrup and water, may be scattered in infested areas.

Cotton Aphid or Louse. The cotton aphid is sometimes destructive, but ordinarily the cotton crop survives the attacks of this pest. If it is desirable to repel or eradicate the lice, nicotine dust at the rate of 6 to 9 pounds per acre may be used.

Cotton Flea Hopper. The cotton flea hopper causes the destruction of very small squares by puncturing them. This results in the failure of the plants to produce flowers. The hoppers may be controlled by dusting with finely ground sulphur at the rate of 10 pounds per acre.

Red Spider. Occasionally the red spider attacks cotton plants. The spider sucks the juices of leaves from the underside. Spraying the undersides of the leaves with a solution of potassium sulphide is an effective method of control. Lime-sulphur or fish-oil soap sprays are also effective.

Cotton Wilt. Cotton wilt is a disease of cotton which occurs chiefly on sandy and sandy loam soils. The leaves of the diseased plants wilt and fall. On examination, the interior of the stems and roots show a dark brown or black color. The planting of wilt-resistant varieties or strains of cotton appears to be the only means of avoiding losses from this disease in areas where the disease is present.

Root Knot. Small nematodes or eelworms which bore into the roots of cotton plants result in root knots, or irregularly shaped swellings on the roots. This condition occurs primarily on sandy soils and is often associated with the cotton wilt disease. Injury from the nematodes may be prevented by crop rotation in which crops, resistant to nematode injury, are used in the rotation with cotton.

Other Cotton Diseases. Cotton rust is a common disease. The condition seems to be caused by a lack of certain chemical elements in the soil. Applications of potash to the soil sometimes appear to be helpful.

Anthracnose in cotton is caused by a fungus which lives over winter in diseased stalks or is spread by infected seed. The disease may be controlled by treating the seed and by planting in fields not infected from old cotton stalks. Cotton is also susceptible to a bacterial blight of the leaves and various root rots.

Botanical Classification and Characteristics of Cotton. Cotton belongs to the *Malvaceae* or mallow family of plants and to the genus *Gossypium. Gossypium hirsutum* is the American upland cotton while the sea island cotton is classified as *G. barbadense.* These two species include practically all the cotton produced in the United States. Many other species are recognized, but their production is of little commercial importance in this country.

Cultivated cotton is annual or biennial in growth. The plants have tap roots with many branches. The roots penetrate 2 to 4 feet in the soil. The main stems are erect and branching, with the plants attaining heights of 2 to 3 feet. Cotton plants produce both vegetative branches and fruit branches, arising from axillary buds. The leaves are arranged spirally and are petroled, palmate, and have three, five, seven, or even nine lobes.

The flower buds, borne on the fruiting branches, are subtended by a growth of three, sometimes four, leaflike bracts. Buds with their bracts are called *squares.* The flowers are large and vary in color, being white, yellowish, or reddish, depending upon the age and the variety of the flowers. The ovary has three to five divisions called *locks.* There is a style and stigma for each lock in the ovary. The

stamens arise from a tubular structure which surrounds the pistils. The flowers of cotton may be either cross- or self-fertilized. The fruit develops in capsule form, containing the locks, each with seed and fiber. The capsules are called *bolls,* and upon approaching maturity break open, exposing the seed cotton.

Each of the locks in a boll contains six to ten seeds, and each seed is covered with a growth of fibers, each fiber being a hairlike cell extending from the seed coat. The long fibers are called *lint* or *staple.* The seeds of American upland cottons are also covered with very short fibers termed *fuzz* or *linters.* The seeds of island cottons produce no fuzz, consequently after each cotton is ginned, the seeds are practically naked except possibly at the ends.

As the fibers increase in length and approach maturity, the circular form gives way to a somewhat flattened condition. The processes of growth and maturation also bring about an irregular, twisted condition of the fiber, amounting to several hundred twists per inch in the case of mature fibers. The twist in cotton lint is an important factor in the spinning quality of cotton.

Upland short staple cotton fibers are somewhat less than an inch in length; long staple upland cotton may have fibers up to 1½ inches in length; while sea island cotton fibers may attain a length of 2 inches.

About two-thirds of the weight of seed cotton as it is picked from the bolls is due to the seeds. It requires about 1500 pounds of seed cotton to produce a bale (500 pounds) of lint.

Origin and History of Cotton. J. O. Ware, writing in the 1936 Yearbook of Agriculture (176), states that scientists who have investigated the matter point out that there were two general centers of origin of cotton, one in the Old World and one in the New World. Indo China and tropical Africa seem to be the old world centers of origin. In the New World, cotton either might have originated independently in two regions—Mexico or Central America, and the foothills of the Andes Mountains of South America—or might have developed along different lines in these two regions. The cultivated cottons of today seem to trace back to cottons grown in ancient times in one or another of these four world centers. Archeological specimens indicate very ancient usage of cotton in Mexico and in South America, and indigenous species in the Old World furnish some evidence of the double origin in that hemisphere.

While the three types of cotton now grown in this country—sea island, American-Egyptian, and upland—are all probably of Ameri-

can origin, it would seem that the sea island and the American-Egyptian originally came from South America, and that all the upland varieties either came originally from Mexico or arose, at some time in the past, from crosses of Mexican and South American species.

Varieties of Cotton. There are a very large number of varieties and strains of cotton. The present varieties are practically all of hybrid origin. The spreading of the boll weevil over the Cotton Belt shifted the emphasis in production to early maturing, short-stapled varieties because the weevil made it impossible to grow late-maturing varieties.

The 1936 Yearbook of Agriculture contains detailed information pertaining to the development of various strains and varieties of cotton.

Varietal recommendations are to be found in Table 51 of the Appendix of this book.

Areas of Cotton Production. The boundaries of the Cotton Belt are indicated by the map in Fig. 134.

Cotton-Production Statistics. Statistical information relating to cotton production is to be found in Table 37.

TABLE 37 *

COTTON: ACREAGE, PRODUCTION, AND VALUE, 1934 TO 1940

Year	Acreage in Cultivation, July 1	Acreage Harvested	Average Yield per Acre	Production	Season Average Price per Pound Received by Farmers	Farm Value
	(1000 acres)	(1000 acres)	(Pounds)	(1000 bales)	(Cents)	($1000)
1934	27,860	26,866	171.6	9,636	12.36	595,615
1935	28,063	27,509	185.1	10,638	11.09	590,136
1936	30,627	29,755	199.4	12,399	12.33	764,432
1937	34,090	33,623	269.9	18,946	8.41	796,179
1938	25,018	24,248	235.8	11,943	8.60	513,638
1939	24,683	23,805	237.9	11,817	9.09	536,923
1940	24,871	23,861	252.5	12,566	9.41	590,824

* United States Department of Agriculture, Agricultural Statistics, 1941.

Since cotton is an important export crop, it is of interest to consider production statistics on a world basis. Such information is presented in Table 38.

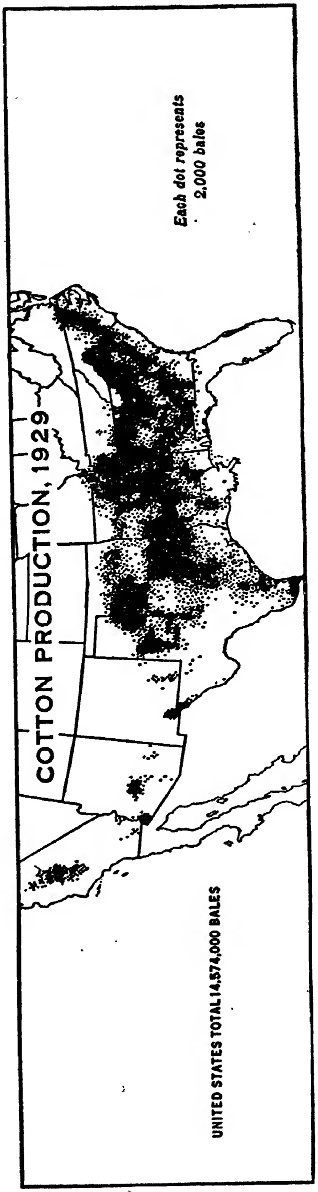

COTTON PRODUCTION, 1929
Each dot represents
2,000 bales
UNITED STATES TOTAL 14,574,000 BALES

FIG. 134.

TABLE 38 *

Cotton: Production, World and Selected Countries, 1934 to 1938

Year Beginning August	Estimated World Total, Including China	Production in Selected Countries										
		United States	India	China	Union of Soviet Socialist Republics	Egypt	Brazil	Peru	Mexico	Argentina	Uganda	Anglo-Egyptian Sudan
	(1000 bales)	(1000 bales)	(1000 bales)	(1000 bales)	(1000 bales)	(1000 bales)	(1000 bales)	(1000 bales)	(1000 bales)	(1000 bales)	(1000 bales)	(1000 bales)
1934	23,840	9,636	4065	3243	1738	1566	1328	345	223	295	212	227
1935	26,750	10,638	4965	2667	2250	1769	1757	393	251	373	272	201
1936	31,320	12,399	5285	3870	3400	1887	1824	386	395	144	269	268
1937	38,225	18,946	4867	3600	3700	2282	2075	376	340	237	349	264
1938	28,400	12,008	4400	2300	3800	1523	1877		260	300	250	243

* United States Department of Agriculture, Agricultural Statistics, 1941.

During the period 1927 to 1936, Texas produced an average per year of 3,997,000 bales of cotton; Mississippi, 1,462,000; Arkansas, 1,182,000; Alabama, 1,159,000; Georgia, 1,152,000.

Cotton Research. Research pertaining to the production and uses of cotton is of great significance in connection with this crop. Some concept of the nature of the research program may be gained from the following information, found in Senate Document 65 (130).

Fiber obtained from the cotton plant is of two distinct types (1) cotton lint, composed of the longer fibers separated from the seed at the gin, and (2) cotton linters, composed of the shorter fibers remaining on the seed after ginning and later removed with varying degrees of completeness by special machinery at the cotton-seed oil mills. More than 98 per cent of the lint cotton is spun into yarns, whereas only a very small proportion of the linters is spun. In this country, more than half the linters is used in batting, wadding, mattress felts, and other padding materials, but most of the exported linters, which has been around 15 to 20 per cent of the total domestic supply during recent years, is reported to go into chemical uses. The proportion of linters to lint, by weight, seldom exceeds 1 to 10.

Production Research

1. Breeding and genetic researches to develop varieties and strains high in yielding capacity, of fiber length, and quality satisfactory for specified uses, resistant to diseases, insects, and other factors adversely influencing yield and quality, and best adapted to the various sections of the cotton-producing area. Specific objectives include greater uniformity of fiber properties, production

of cotton with seed of a higher oil content, improved adaptability for mechanical harvesting, and suitability for specific uses such as automobile tires.

2. A number of studies in morphology and developmental anatomy, such as an investigation of the causes of immature fiber and other fiber imperfections.

3. Studies of the most important pests and diseases, including the boll weevil, bollworm, root rot, and cotton wilt.

4. The relationship of yield to quality (length, fineness, strength, etc.) and the influence of soil, irrigation, fertilization, type of culture, climate, and other environmental factors upon both yield and quality. Other points being studied are the dependence of fiber qualities on the density of growth of the fiber on the seed, and the influence of soil and stage of growth on the chemical composition of the plant. Hydroponics is receiving some attention.

5. Studies of methods designed to lower the cost of production.

6. Engineering studies on the development of cotton production machinery, especially of a satisfactory harvesting machine.

Ginning Methods and Equipment

7. Intensive and extensive research on ginning machinery and methods of operation with the purpose of obtaining more efficient and economic handling and ginning of seed cotton, of minimizing damage to the lint, and of securing a superior preparation: These investigations include research on both saw and roller gins and on improvements in cleaning, extracting, and drying equipment.

Research on Fiber Properties

8. Intensive research on the physical properties of cotton fibers and the relation of these properties to cotton utility: Among the properties receiving attention are color, length, fineness, maturity, strength, adsorptivity, and elasticity. Special studies are being made of the relations between the fiber properties and their cell-wall and cross-sectional structure. Much of this research is being carried on with a view to setting up new and improved quality standards for raw cotton.

Processing Machinery and Methods of Manufacture

9. Limited studies designed to develop entirely new machinery and methods for processing cotton into yarns and fabrics: Most of the research in this field is confined to improvements in existing machinery and in the technique of manufacture. All such work is aimed toward lowering the cost of manufacture or improving the quality of the product, or both.

Yarn and Fabric Development

Work in developing new and improved yarns and fabrics: The results of research along this line are typified by the new clothing and household fabrics that are brought on the market each year, by new types of fabric for automobile tires, and by various innovations in bags for packaging merchandise. Specific examples are men's cotton slacks for summer wear, open-mesh bags

for packaging fruits and vegetables, cotton bagging for covering cotton bales, cotton fabrics for reenforcing bituminous-surfaced roads, and cotton mats for curing concrete. Research on many such fabrics does not end with the development of the fabric, but often continues with the purpose of further improving the utility of the fabric or else in reducing the cost of manufacture. The results of commercial tests indicate the desirability for further work.

Research now in progress on the development of new and improved cotton yarns and fabrics is conveniently classified under the following headings.

10. Industrial fabrics: Approximately 40 per cent of all the cotton consumed in the United States each year goes into industrial fabrics. Specific objects of research in this field include a cotton twine suitable for tying letters and parcels in connection with the handling of mail; a more durable cotton tire fabric, especially for use in high-speed, heavy-duty truck and bus service; various types of cotton bagging for covering cotton bales, cotton bags for packaging certain agricultural commodities not now handled in cotton bags; cotton fabrics for reenforcing bituminous-surfaced roads, cotton mats for curing concrete, and fabrics for use in preventing erosion on seeded slopes; cotton shroud cords for parachutes, to replace those now made with silk.

11. Clothing and household fabrics: Approximately 60 per cent of the cotton consumed in the United States goes into clothing and household fabrics, with clothing alone accounting for about 40 per cent, or about the same as industrial uses. Research in this field is concerned mostly with the development of special yarns and weaves, either of cotton alone or of cotton mixed with other fibers. New types of cotton hosiery, underwear, curtains, and summer clothing are typical examples of objects of research in this field.

Finishes and Treatments

Finishes and treatments for cotton textiles may be divided into two main classes—those which are applied during intermediate stages of the manufacturing process to facilitate processing or handling, and those which are applied to finished yarns and fabrics for the purpose of altering their natural properties for specific uses. Research in progress on treatments of the first type is concerned mainly with various types of starches used for sizing yarns preparatory to weaving, but there is also some work being done with other sizing material. Gelatine and other proteins are among those now being studied.

Research on finishes of the second type is quite varied. Most of the new and improved finishes on which work is being done may be classified as follows:

12. Mercerization; specifically the use of cuprammonium or other alkaline solutions in the place of sodium hydroxide, the reaction to mercerization of fabrics, consisting of mixed fibers, and change in composition of the fiber during mercerization.

13. Permanent shrinking of cotton fabrics, either by chemical or mechanical treatment, or some combination of the two, with the particular aim of finding less expensive methods than those now used.

14. New and more efficient methods of waterproofing, among the particular materials under investigation for this purpose being grease, oil, wax, heavy metal soaps, tar, asphalt, rubber, varnish, paint, lacquer, and resins.

15. Finishes of special applicability to clothing and household fabrics, such as those designed to improve the hand and draping properties, to increase resistance to creasing and soiling, to improve the luster, and to provide fabrics with greater stiffness for certain uses: Problems associated with the printing and dyeing of cotton fabrics, of paramount importance in this field, are receiving a great deal of attention. At present, most of the research along these lines makes use of such substances as urea-formaldehyde, vinyl and acrylate resins, protein and starch sizes, cellulose ethers and esters, cellulose dispersions, and strong acids (which produce hydrocellulose).

16. Miscellaneous finishes and treatments: In addition to work referred to above, research is also being done on finishes to increase the resistance of cotton fabrics to the action of fire, acids, microorganisms, and light, and to improve the adsorptive properties for certain uses.

Testing and Standardization

17. Research on the development of testing methods, standards and specifications for fiber, yarns, and fabrics: In particular, the correlation of physical and chemical tests on cotton with the spinning value, the quality of yarn, and fabric, and the performance of the fabric is being studied. Rapid methods are being sought for the determination and measurement of the qualities of raw cotton. Particular tests being studied are determination of moisture adsorption, tensile strength, per cent elongation, pliability, fineness, length, maturity, variation of these properties, fluidity in cuprammonium solution, luster, dielectric constant and other electrical properties, resistance to dyeing, bleaching, preoxidation, alkali solubility, copper number, and accelerated aging. The reliability and speed of spinning tests are being increased. The use of X-rays as a method of measuring the strength of raw cotton is being investigated. The identification of fibers in fabrics is also a subject of much interest. Specific work in this line includes the use of fluorescence as an aid and the development of a satisfactory microtome.

Economic Research

18. Studies of the general factors of demand affecting the total and per capita consumption of American cotton and of competing growths and other fibers: Attention is being given to factors operating in foreign markets as well as to those which apply especially in domestic markets. Studies more basic than these to an understanding of the utilization of cotton are those which follow the consumption of cotton for specific uses, determining both the quantity and quality of cotton going into them as well as the set of demand factors peculiar to each use. What is usually referred to as "market analysis" is included in this type of work. Lastly, there are economic studies which view the entire cotton industry as an entity and seek to evaluate the relative efficiency with which various types of economic organization within the in-

dustry operate. Economics embraces such a broad field that the large amount of research being conducted has been outlined in only the most general terms.

Miscellaneous Research

In addition to the aforementioned research, considerable work is being done that does not fall strictly within any one of the foregoing classifications. This may be classified as follows:

19. Development of a satisfactory device for the permanent identification of individual bales of raw cotton, to be applied at the gin, to facilitate the handling and marketing of cotton.

20. Studies of a method to take a representative sample of lint automatically during the ginning process.

21. Investigations to find a use for the wax on cotton fiber: Byproducts from the ginning process are being considered elsewhere in this report.

22. Investigation of many types of laminated products, including bonded metal where cotton or other fabric is faced on metal backgrounds by pressing it into a surface film of melted tin; decorative panels consisting of cotton fabric glued onto wood veneer; and laminated products of unspun cotton and light-weight fabric using cheap adhesives.

23. Research directed toward more efficient and less damaging methods in the cleaning and laundering of fabrics: The increased use of deodorants and depilatories is responsible for research aimed at the prevention of damage to clothing from this cause.

24. Cotton rags are used to a large extent in the manufacture of paper, fiberboard, and roofing felt. The presence of rubber in some of the newer composite fabrics has prompted the study of its removal prior to such reuse. An outlet being developed for dyed rags consists of pulverizing them for use in decorative finishes.

25. Compilation of a bibliography of hundreds of different present and potential uses of cotton and cotton linters.

Cotton Linters

While the principal use of cotton linters is for padding and stuffing, practically all of the research is devoted to the preparation and utilization of its chemical derivatives. For this purpose the linters is specially cleaned and purified to form what is known as chemical cotton, which is one type of industrial cellulose. Pulpwood is the only other major source of industrial cellulose, and for some purposes wood cellulose derivatives are replacing chemical cotton.

Owing to the extreme importance of rayon as a competitor of cotton and the fact that it represents the largest single outlet for chemical cotton, it will be given a detailed treatment similar to that for lint cotton.

Of the three commercial types of rayon produced in this country, acetate and cuprammonium are manufactured from cotton linters, while viscose is now prepared almost entirely from wood pulp.

Although not specifically mentioned, much of the research in progress on viscose rayon is also covered in this section, as the research on this material is, in many cases, identical with that on the other types of rayon. Furthermore, except for some special cases, it will not be necessary to discuss separately the research on transparent sheeting and film, as, up to a certain point, this research is practically the same as that devoted to the manufacture of rayon itself.

Comparatively little research is being conducted on raw linters and chemical cotton, but studies on rayon and other derivatives of chemical cotton are extremely numerous and varied.

CHAPTER XXVII

POTATOES

The potato crop of the world is used, probably more than any other crop grown, for direct human consumption. Though a comparatively new crop, being of American origin and introduced into Europe, the potato crop now makes up a large portion of the food of Europeans and Americans.

Efficiency in potato production depends upon the attention which is paid to a number of production factors and practices. Large yields per acre are obtainable if adequate attention is given to all aspects of production.

Climatic and Soil Factors in Potato Production. Potatoes are grown over a very wide range of soil and climatic conditions although the crop is best adapted to the lighter type of soil under moist, cool conditions of climate.

Loam soils, ranging from those of a fine sandy type to silt loams with good underdrainage, are most suitable. The soils should be especially well aerated and at the same time should have excellent moisture supplies. When potato scab is prevalent, it is advisable to grow potatoes on soils somewhat acid in nature. Potatoes do well, however, on less acid or slightly alkaline soils if potato scab can be avoided.

Potato production requires a high state of soil fertility if large yields are to be realized.

Rotations for Potatoes. According to an Ohio publication (160), the primary aim in a rotation for potatoes is to have, preceding the potatoes, a green-manure crop that will leave the soil in a loose, friable condition. It is further pointed out that there is some need for special rotations because potatoes produce best in an acid soil, contrary to general farm crops. If potatoes follow a timothy-clover sod, there is the danger from wireworm and grub injury.

For early potatoes a rotation method which seems to be increasing in Ohio, on soils in good physical condition, is to sow winter barley or rye immediately after early potatoes are harvested. Then the

grain crop is plowed under the following spring. On soils not in such good physical condition and for late potatoes, a two-year rotation is commonly used. Potatoes followed by wheat seeded to clover is a common rotation. Sweet clover and alfalfa are suitable for soils that have a high lime content or that are very fertile, while mammoth red clover and alsike clover have been found suitable on soils that are more acid.

Under western conditions, such as exist in Colorado (101), it has been found advisable to grow potatoes in definite rotations that contain alfalfa. An Illinois publication (117) recommends the use of sweet clover in the rotation because it decomposes rapidly when turned under and furnishes an abundance of nitrate nitrogen and organic matter.

Fertility Requirements for Potatoes. Although the practices of supplying manure and fertilizer in potato production vary to a great extent, dependent upon locality and soil conditions, yet a general idea of procedures may be gained by citing information obtained from a number of sources.

Table 39, from an Ohio publication (160), indicates the amount of nitrogen, phosphoric acid, and potash to be found in a 400-bushel crop of potatoes.

TABLE 39*

NITROGEN, PHOSPHORIC ACID, AND POTASH IN A 400-BUSHEL CROP OF POTATOES

	In the Tubers	In the Tops	Total Pounds
Nitrogen	84	100	184
Phosphoric acid	32	11	43
Potash	140	90	230

* Ohio Agricultural Extension Service, Bulletin 86.

For early potatoes, grown year after year with winter cover crops, and for late potatoes in a two-year rotation, the Ohio Agricultural Extension Service (159) recommends fertilizing in the following manner: early crop without manure, 1500 pounds 6–8–6; late crop without manure, 1500 pounds 4–8–6; on muck soils without manure, 1000 pounds 0–8–24. It is stated that, for each ton of good quality manure used, the commercial fertilizer requirements may be reduced 50 to 75 pounds.

These recommendations are general and must be modified according to the specific conditions faced by the grower.

In a special bulletin on Soil Management for Potatoes (54), the Michigan Agricultural Experiment Station states that, in general for that state, potatoes are grown on sandy loam and loam soils which are not particularly high in fertility elements. It is suggested that manure plus a 4–16–8 commercial fertilizer is an excellent combination for potatoes. On sandier soils it is pointed out that a 3–12–12 mixture may give better results.

Considering the cost of fertilizer, the danger of drought and the uncertainty of potato prices, applications of 500 to 600 pounds per acre of commercial fertilizers are suggested for use.

The average yields from different methods of applying fertilizers to potatoes are presented in Table 40 from the 1938 Yearbook of Agriculture (178). It may be concluded from the facts presented in this table that fertilizer is best applied in two bands, approximately 2 inches wide, placed on each side, 2 inches from and about level with the lower plane of the seed piece.

TABLE 40

Average Yields from Different Methods of Applying Fertilizers to Potatoes

State	Period	Average Yields with Fertilizer Placed		
		At sides of seed piece *	Band under seed †	Mixed in row ‡
	(Years)	(Bushels)	(Bushels)	(Bushels)
Maine	4	392	357	349
Michigan	5	203	188	177
New Jersey	5	274	230	250
Ohio	4	238	226	225
Virginia	4	248	215	228

* In side bands, 2 inches from and slightly below level of seed piece.

† In band, 4 to 5 inches wide, approximately 1 inch directly below seed piece.

‡ In row, well mixed with soil throughout cross-sectional area, about 5 inches wide and 2 inches deep, with seed piece located at the center.

Potato Seed Quality. Success in potato production depends in a large degree upon the quality of seed that is used. Good seed must be practically disease-free, of a standard variety free from mixtures, of a high yielding strain, and be handled in such a manner as to be in the proper condition for planting.

A number of factors must be considered in the securing of high quality seed and the preparation of the seed for planting.

Seed Sources. Seed potatoes produced in the Northern States and in some of the Canadian provinces are commonly used in commercial potato production. The certified seed from these areas that has been produced under rigid rules and inspections by state authorities provides growers with seed of definitely high quality. In the states immediately south of the seed-producing areas, good seed potatoes may be produced if particular attention is given to production practices

FIG. 135. The two potato plants at the left are infected with blackleg. Such plants should be removed from the field as soon as they are discovered. (*Idaho Agricultural Experiment Station.*)

and disease control. A common plan is to secure certified seed to plant a plot large enough to provide sufficient seed for the commercial acreage the succeeding year. When this method of securing seed for commercial plantings is used, it is important to secure the best certified seed that is obtainable and to rogue the diseased and weak hills from the field. It has also been found advisable to plant stock intended for use as seed at a later date than when the crop is intended for commercial purposes.

Under Ohio conditions (160), it is suggested that seed plots be rogued first when the plants are about 1 foot high, again just before the vines fall over, and later just before digging. It is important to remove the vines and tubers from the field of all plants that show diseased or abnormal growth.

Seed Treatment. If scab and rhizoctonia are found to be present on the surfaces of seed potatoes, then it is important to disinfect the seed. This may be done by using commercial materials according to the directions provided by the manufacturer, or by securing various

materials and making disinfecting solutions. A very good solution for instantaneous treatment may be made by mixing 2 pounds of yellow oxide of mercury in 30 gallons of water. Another solution may be prepared by dissolving 4 ounces of corrosive sublimate in 30 gallons of water. Detailed directions for the use of such solutions usually may be secured through the agricultural extension services in states where potato growing is important.

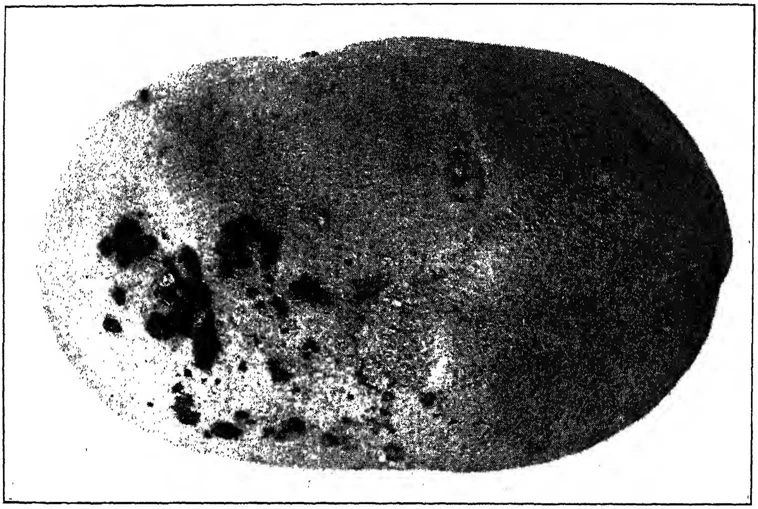


FIG. 136. The black spots on the potato are the sclerotia of the disease rhizoctonia. Difficulties with this disease may be avoided by using clean seed or by treating potatoes that are to be used for seed. (*Idaho Agricultural Experiment Station.*)

Cutting Seed. Small, whole-seed potatoes may be used if they are derived from clean, vigorous stock. The common practice, however, is to cut seed in preparation for planting. Investigations reveal that blocky seed pieces, weighing 1 to 1½ ounces, are most suitable. Ideally, each seed piece should have at least one eye or bud that is centrally located.

When seed is to be cut and planted immediately, little trouble may be expected if the seed pieces are protected from dry winds or direct sunlight. If large quantities of freshly cut seed pieces are taken to the field, it is essential to keep the material covered. Wet sacks may be used to advantage for covering material.

The process of cutting seed with a view to healing it before planting requires care and experience. Equipment needs to be available

which will permit holding the seed for ten days at a temperature about 60 degrees Fahrenheit with a relative humidity of about 85 per cent. After such a period, the temperature and humidity may be lowered, but if the seed is to be held for some time, it should be placed in cold storage.

Green Sprouting of Seed. Under some conditions it is a profitable practice to green-sprout potato seed. According to a Cornell publication (57), the principal effects of green sprouting are: earlier emergence after planting; more rapid early season growth; fewer stems per plant; more tubers per stem; a higher percentage of United States No. 1-sized tubers; a slightly significant increase in total yield.

Green sprouting may be accomplished by spreading uncut potatoes in a layer about three tubers deep on a barn floor or other suitable place for a period of ten days to two weeks. The place must be well lighted and kept at about outdoor temperature.

Fig. 137. The black parts of the stems of these young potato plants are lesions caused by the disease rhizoctonia. (*Colorado Agricultural Experiment Station.*)

Potato Seed-Bed Preparation. A good seed bed for potatoes should be deep because of the need for planting the seed pieces at depths ranging from 3 to 5 inches. The seed bed should also be rather loose and mellow because of the particular effect of good soil aeration on potato production. Spring or fall plowing at depths of 7 to 10 inches, depending upon conditions, constitutes the usual procedure. Sometime before planting, the plowed land is harrowed to level the soil and fill spaces. Immediately before planting, it is advisable to use a deep-tilling machine, such as a rigid-toothed, orchard cultivator, or a deep-running, spring-tooth harrow, to stir the soil at the bottom of the seed bed.

Planting of Potatoes. Early varieties of potatoes are usually planted just as early in the spring as the ground can be prepared. Late potatoes in the regions where they are commonly grown are planted during the latter part of May or in early June.

In heavy soils, potatoes may be planted about $3\frac{1}{2}$ to 4 inches in depth, while in light soils the planting depth may well be 4 to 5 inches. It is important that seed pieces be planted sufficiently deep because the tuber-producing stolons form above the seed pieces.

There are various types of planters, but most of them are equipped with discs which may be adjusted to throw a ridge of soil over the seed pieces. It has been found good practice to adjust the discs to

Fig. 138. This is a cup-type potato planter which is best adapted to the handling of whole rather than cut seed. (*Colorado Agricultural Experiment Station.*)

throw a shallow covering of soil over the seed pieces and to depend on the subsequent cultivating operations to cover the seed pieces further as growth takes place.

The distance between rows usually varies from 30 to 36 inches, and the spacing of seed pieces in the row may vary from 9 to 16 inches. On very fertile soils, shorter spacings are used. Early varieties of potatoes are spaced closer than are late varieties.

The amount of seed required per acre is indicated in Table 41, selected from an Ohio publication (160).

Cultivation of Potatoes. If rain occurs soon after planting and causes the soil to become packed, it is essential to use a harrow or weeder. The ground should be kept loose between the time of planting and plant emergence in order to prevent the rotting of seed pieces. As soon as plants can be seen in the row, it is well to provide for a deep cultivation, close to the plants. This should be followed by the

TABLE 41*

AMOUNT OF SEED REQUIRED PER ACRE

Rows 32 Inches Apart	Weight of Seed Pieces and Amount of Seed Required per Acre in Bushels	
	1 ounce	$1\frac{1}{2}$ ounces
Bushels required 9-inch spacing	22.6	33.9
Bushels required 10-inch spacing	20.4	30.6
Bushels required 12-inch spacing	17.0	25.5
Bushels required 14-inch spacing	14.6	21.9

* Ohio Agricultural Extension Service, Bulletin 86.

use of a weeder. After the first cultivation, in order to control weed growth and provide for soil aeration, the weeder is commonly used in combination with shallow working with a cultivator.

When potatoes have been planted at suitable depths, it is usually best not to follow the practice of hilling. If seed pieces have been planted in a very shallow manner, it may be necessary to adjust cultivating operations to throw soil into ridges about the plants.

Spraying Potatoes. The spraying of potatoes for the control of insects and diseases is paramount in potato production. Leafhoppers, flea beetles, and Colorado potato beetles are the principal insects to be controlled. Early and late blight are diseases which often cause serious losses.

Potatoes are usually sprayed with Bordeaux mixture, to which is added a poison to control chewing insects. The Bordeaux mixture prevents the growth of foliage diseases and acts as a repellent to many insects. Rather recent experiments have demonstrated that, when potatoes are sprayed with Bordeaux mixture, a small amount of copper is absorbed by the leaves and is to be found in the sap of the plant. When leafhoppers suck sap from plants sprayed with Bordeaux mixture, the small amounts of copper in the sap destroy the insects.

Bordeaux mixture is made by combining copper sulphate, lime, and water. To accomplish this satisfactorily, a stock solution is made by dissolving 50 pounds of copper sulphate in 50 gallons of water. Another stock solution is made by placing 75 pounds of fresh, hydrated lime in 50 gallons of water. One hundred gallons of spray material

are made by mixing 8 gallons of copper sulphate stock solution and 12 gallons of lime water with 80 gallons of water. If it is desired to control chewing insects, 4 pounds of calcium arsenate may be added.

Spraying should begin when the plants are a few inches high and should be continued every week during the growing season. It will require about 75 gallons per acre for thorough coverage for the first

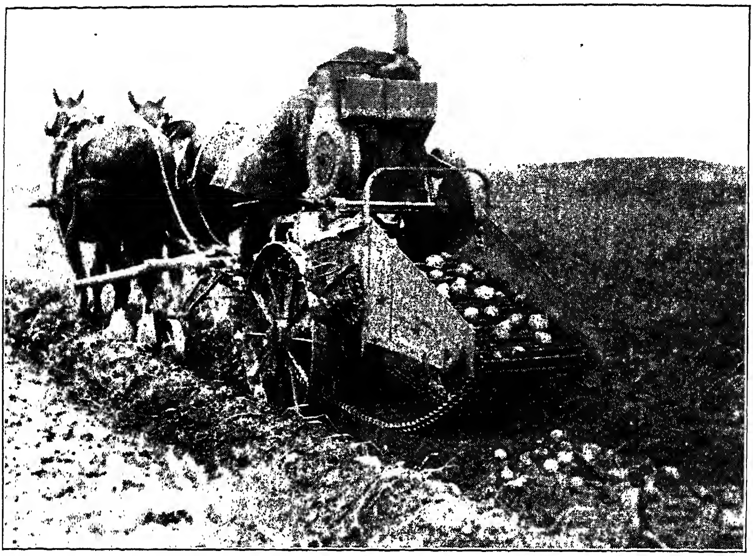


FIG. 139. When power equipment is used to dig potatoes, care must be exercised to avoid mechanical injury of the tubers. (*Maine Agricultural Experiment Station.*)

sprayings. Midseason sprayings will require about 100 gallons, but 150 to 175 gallons will be necessary for the late applications. The spray should be applied with machines which will provide about 400 pounds of pressure. It is important to use nozzle adjustments which will result in covering both sides of the potato leaves.

Spraying is a profitable operation. At the Ohio Station (159), it was found that the average increase for spraying over a thirteen-year period was 107 bushels per acre.

Dusting Potatoes. The dusting of potatoes in the control of insects and diseases does not seem particularly practical for large acreages, but may be economical and efficient for small areas. A dust, consisting of 80 parts of hydrated lime and 20 parts of monohydrated copper sulfate, may be used. When the flea beetle needs to be controlled,

the mixture should consist of 70 parts of hydrated lime, 20 parts monohydrated copper sulphate, and 10 parts calcium arsenate.

The dust should be thoroughly mixed and applied with a duster in the morning or evening when the plants are wet with dew. Applications should be made about every week during the growing season. The first applications will require about 25 pounds per acre, whereas the late season applications will require from 50 to 60 pounds of the dust.

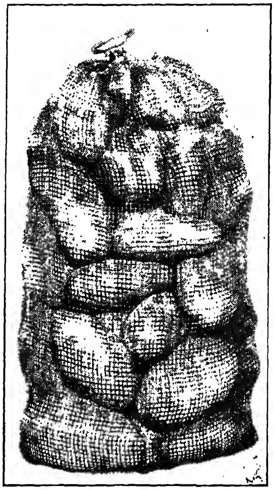


Fig. 140. It is becoming common practice to offer potatoes to the retail trade in small sacks or packages. (*Colorado Agricultural Experiment Station.*)

Potato Harvesting. Unless there is some particular reason for harvesting potatoes before the time of their full maturity, it is more satisfactory to harvest at full maturity because the periderm or skin of a mature potato is resistant to injury. Even with mature potatoes, it is essential to use great care in harvesting in order to reduce the amount of mechanical injury. Skinned, bruised, or cut tubers are subject to greater shrinkage; organisms of disease and decomposition have more opportunity for destruction; and the market qualities of such stock are greatly reduced.

It has been found important to avoid the sun scalding of potatoes which occurs when potatoes are allowed to remain in direct sunlight after digging. The harvesting operation should be managed in a manner to prevent such exposure.

Potato Sizing and Grading. When potatoes are to be marketed, it is important that small potatoes be eliminated and that potatoes of poor grade, because of injury, disease, or growth conditions, be removed.

Federal grades for potatoes have been established, and it seems important that these grades be used as a means of bettering the marketing conditions for potatoes. The grades which have been defined are United States Fancy, United States No. 1, United States Commercial, United States No. 2, and Unclassified. The last classification refers to potatoes which have not been graded according to the standards that have been established.

Storage of Potatoes. Under ideal conditions, storage facilities should be available which will permit storing potatoes at about 60

degrees Fahrenheit and 85 per cent humidity for the first 10 days. During the rest period or dormant stage of potatoes, which extends for about three months after maturity, potatoes may be held at temperatures about 60 degrees. Following the period of dormancy, potatoes begin to sprout unless the temperature can be dropped to about 40 degrees.

Where large quantities of potatoes are to be held in storage, it is important to have suitable storage-house construction, adequate means of storage facilities within the structure, as well as adequate means of ventilating and of controlling temperature and humidity.

Potato Insects and Diseases. Although the potato crop is subject to the attacks of many insects and diseases, yet the means of control have been found, and when care is taken to use the information which has been made available, serious losses usually may be avoided and large yields can be obtained.

The difficulties which may arise from infestations of white grubs and wireworms may be controlled largely by cultural practices in the management of soils for potato production. Common scab and rhizoctonia are diseases which may be controlled through seed selection and seed treatment. A spraying program, if conducted efficiently, may be expected to control early and late blight diseases or such insects as the Colorado potato beetle, potato leafhoppers, potato flea beetles, potato aphids, and blister beetles. Numerous diseases may be avoided by using seed which has been produced as disease-free

Botanical Classification and Characteristics of Potatoes. Potatoes, *Solonum tuberosum,* belong to the Solanaceae family of plants, which includes, in addition to potatoes, such crops as tomatoes, eggplants, and tobacco.

The potato is a perennial plant in its growth habits, but is handled as an annual so far as cropping practices are concerned. The root system of the plant is many branched and inclined to be of a fibrous type. Although most of the root formation is near the surface of the soil, the roots may extend to depths of 3 or 4 feet. The aerial stems are erect in their early growth but become spreading, procumbent, and somewhat vinelike as maturity is reached. Compound, pinnate leaves are produced. The underground stems or slender rhizomes arise from the underground portions of the aerial stems. Tubers are formed at the ends of the underground stems. The tubers bear buds or "eyes." Many varieties of potatoes grown from pieces of tubers

produce flowers, but under most conditions of culture the globelike potato fruits containing seeds are not formed. Potato seed is sometimes used for plant breeding purposes.

Origin and History of Potatoes. Potatoes were found under cultivation at the time of the Spanish invasions of South America. Wild potatoes are still found growing in many elevated regions of South America. The information relating to the introduction of potatoes into Europe and North America is far from being authentic or exact in nature. According to the 1936 Yearbook of Agriculture (175), potatoes were introduced into Europe about 300 years ago, and in the area occupied by the United States, it has been about 200 years since the first potatoes were introduced from Ireland. The fact that the first importations into this country appear to have come from Ireland no doubt gave rise to the term "Irish" potato.

Potato Varieties. A large number of potato varieties have been developed but the following are the names of those most commonly grown: Irish Cobbler, Triumph, Early Rose, Early Ohio, Russet Rural, Russet Burbank, Rural New Yorker, Green Mountain, Chippewa, Katahdin. The recommended varieties for various states are to be found in Table 51 of the Appendix.

Potato-Production Areas. The distribution of potato production in the United States is presented in Fig. 141.

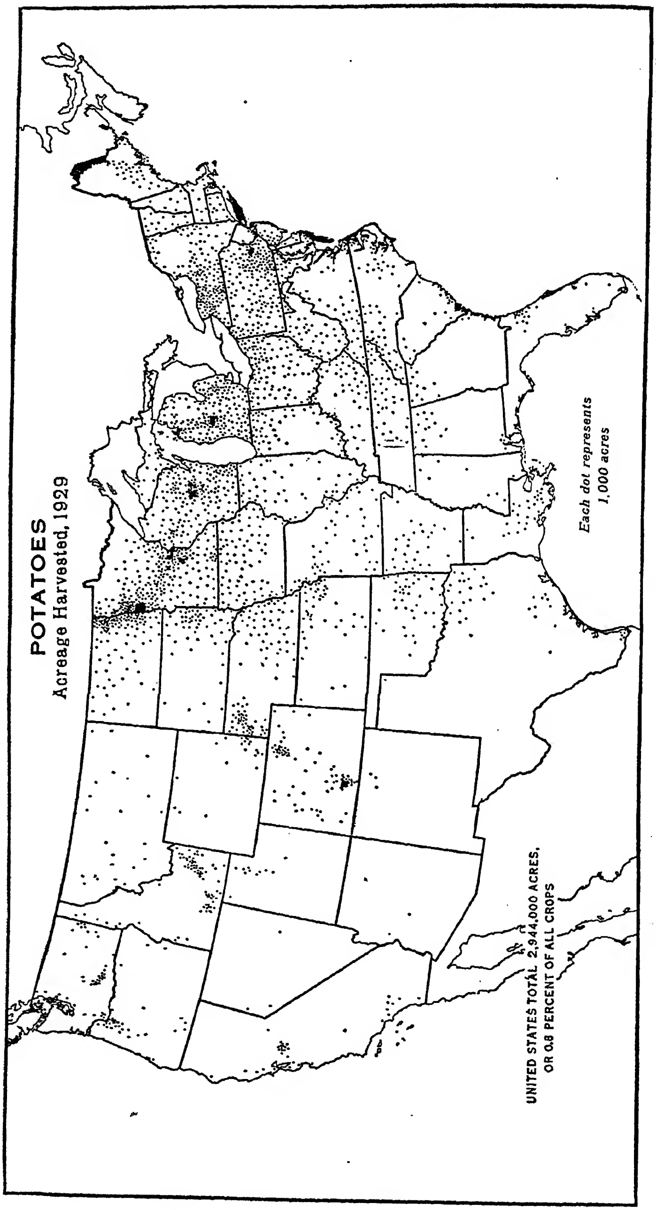
Potato-Production Statistics. The production of potatoes in the United States is indicated by the information to be found in Table 42.

TABLE 42*

POTATOES: ACREAGE PRODUCTION, UNITED STATES, 1934 TO 1940

Year	Acreage Harvested	Average Yield per Acre	Production
	(1000 acres)	(Bushels)	(1000 bushels)
1934	3597	112.9	406,105
1935	3541	109.1	386,380
1936	3063	108.4	331,918
1937	3185	124.1	395,294
1938	3023	123.8	374,163
1939	3018	120.3	363,159
1940	3053	130.3	397,722

* United States Department of Agriculture, Agricultural Statistics, 1941.


POTATOES
Acreage Harvested, 1929
Each dot represents
1,000 acres
UNITED STATES TOTAL 2,944,000 ACRES,
OR 0.8 PERCENT OF ALL CROPS

(U.S.D.A.)

FIG. 141.

Potato Research. Some impression of the present potato research program in the United States may be gained from the following material taken from Senate Document 65 (130).

1. Development of disease- and insect-resistant varieties, varieties resistant to drought and heat, varieties having desirable qualities for food purposes, and varieties adapted to the growing season in various sections of the United States.

2. Determination of the effect of various types of long and short rotations, and the use of winter cover crops with continuous production.

3. Investigations in field-plot technique, depth of planting variety trials, spacing, twin rows, date of planting, size of seed piece, cultivation, irrigation, and root development.

4. Important studies on rates of application; placement; kinds of fertilizers, including a great deal of minor elements work; and on rapid tests for deficiencies in fertilizers.

5. Studies of effects of climatic and soil factors, fertilizers, fumigants, insecticides, and their internal and external influences, on growth of vines and set of seeds and on number, size, culinary quality, chemical composition, and starch content of tubers.

6. Studies on the nature of fungus, bacterial and virus diseases, and on the various insect pests—their control or eradication.

7. Some studies on improved methods for reducing losses of potatoes in storage and for reducing injury in handling; on potato storage diseases, and on the causes of deterioration during storage.

8. Economic investigations on the marketing quality of potatoes, the factors which influence customer preferences, buying practices, price, and demand, as well as studies on the cost of potato production in various localities.

9. Studies on the variation in the cooking and eating quality of potatoes; and on the effect of various cultural, varietal, and environmental factors on potato yields and quality. These studies are being correlated with the composition and physical structure of the potato with the object of improving its quality for food use.

10. Investigations on the vitamins present in potatoes and on the comparison of the Vitamin C content of immature, mature, and stored tubers.

11. Some research on potato-starch production with the object of improving its quality. The uses of potato starch for textile sizing and paper sizing and for alcohol manufacture are also being investigated.

12. Investigations have been conducted on the use of cull potatoes in ensilage and other feeds. In connection with this work some dehydration studies were conducted.

CHAPTER XXVIII

SWEET POTATOES

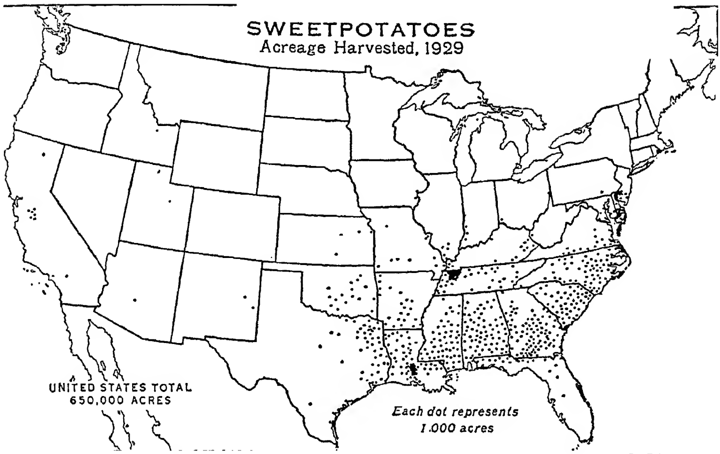
Sweet potatoes, *Ipomoea batatas,* belong to the Convolvulaceae or morning-glory family of plants. The plant is perennial but is cultivated as an annual. The crop is produced to secure the greatly thickened root portions, sometimes called root tubers, which contain large quantities of starch. The stems may be trailing and of a vinelike nature or may consist of rather short, upright stems, depending upon the variety. The leaves are glossy, dark green in color, and are triangular or heart-shaped in form.

Varieties. There are two general types of sweet potatoes. One type has dry and yellowish flesh while the other general type has flesh which is very moist and soft when cooked. The dry or Jersey type, as is frequently designated, is produced in the more northern areas in which this crop is grown. Big-Stem Jersey, Red Jersey, and Yellow Jersey are dry-fleshed varieties. Varieties with moist flesh are the Nancy Hall and Porto Rico.

Sweet Potato Production Statistics. The areas in which sweet potatoes are produced are indicated in Fig. 142.

Sweet potatoes are the second largest vegetable crop in the United States and the largest in the South. The average annual production during the period 1927 to 1936 was 70,274,000 bushels. The production for the year 1938 was 76,647,000 bushels. In the year 1938, the state of Georgia produced the most sweet potatoes. Other important states in production are, in the order listed: Alabama, North Carolina, Mississippi, Louisiana, South Carolina, and Tennessee.

Climatic, Soil, and Fertility Factors in Sweet Potato Production. Sweet potatoes require a season about four months in length in order to reach maturity. This factor limits their region of production quite largely to the Southern States, as revealed by Fig. 142. The crop thrives on the somewhat lighter types of well-drained soils that have a moderate degree of fertility. Very fertile soils result in excessive vine growth and a poor development of the roots.



(U.S.D.A.)

Fig. 142.

Many soils devoted to the growing of sweet potatoes respond very well to the use of various practices in fertilization. Table 43, from a publication of the Mississippi Experiment Station (30), presents the results from the use of different kinds of fertilizer. The tests were conducted on loam soil that had been planted to cotton for approximately 30 years without rotation or legumes. On this soil the use of a complete fertilizer resulted in the largest yields.

TABLE 43

Influence of Fertilization on Total Yield and Grades of Sweet Potatoes

Treatment	Total Yield (Bushels*)		Yield No. 1's, Average 1930 to 1937 (Bushels*)	Percentage Total Yield in Grades Shown		
	Average 1930 to 1937	Average increase over no fertilizer		No. 1	Strings	Jumbo
Complete fertilizer	345.6	102.3	247	71.4	14.6	13.0
No fertilizer	243.3		163	67.0	28.4	3.7
Nitrogen and phosphorus	318.5	75.2	230	72.1	15.3	11.3
Nitrogen and potash	324.8	81.5	238	73.3	15.7	10.2
Phosphorus and potash	267.0	23.7	186	69.7	25.6	3.4
Nitrogen	326.5	83.2	241	73.7	15.7	9.7
Phosphorus	264.5	21.2	186	70.2	24.6	4.3

* A bushel equals 55 pounds.

Results relating to the fertilization of sweet potatoes, obtained at Winton, California, as reported in an extension service publication of that state (120), are indicated in Table 44. The soil in the Winton plot was very light, sandy, and relatively unfertile.

TABLE 44

EFFECT OF SWEET POTATO FERTILIZERS ON YIELD AT WINTON, CALIFORNIA, IN 1932

Fertilizer Used	Rate of Application, Pounds per Acre	Yield in Tons per Acre				Percentage Increase Over Check	
		Culls	Seed	Market	Total	Market	Total
None (check)		0.88	0.57	1.82	3.27		
Nitrate of soda	500	1.00	0.47	2.45	3.92	34.6	19.9
0–12–8 mixture	700	1.13	0.52	2.49	4.14	34.8	26.6
6–9–6 mixture	700	1.11	0.63	3.34	5.08	84.1	55.3
4–10–10 mixture	700	1.22	0.72	3.91	5.85	113.8	78.6
Manure	20,000	0.74	0.78	5.08	6.60	179.1	101.8

Sweet-Potato Plant or "Slip" Production. Much of the success in sweet-potato production depends upon the growing of vigorous disease-free plants to be used for purposes of transplanting in the fields where the crop is to be grown.

Sweet potatoes that are smaller than marketable size may be used for producing plants. Probably it is inadvisable to use tubers that are less than an inch in diameter. Extreme care should be taken to see that the seed tubers selected are free from disease. As a further precaution, the tubers should be dipped in a solution containing corrosive sublimate.

A very simple form of plant bed may be made by spreading the tubers on the ground, one deep, and by covering with a 4-inch layer of sand, light soil, or sawdust. The efficiency of such a plant bed is low. Improvements may be made by putting a frame around the bed and covering with glass, canvas, or muslin.

A better plant bed may be made by preparing a 15-inch pit to be filled with about 12 inches of fresh horse manure and 3 inches of soil. Such a bed, covered with glass, may be expected to produce good results because of the heat generated by the fermenting horse manure.

Another method of supplying heat to promote the growth of the plants is by means of constructing flue beds. The beds are placed on a slope with a firebox at the lower end, with flues running under the

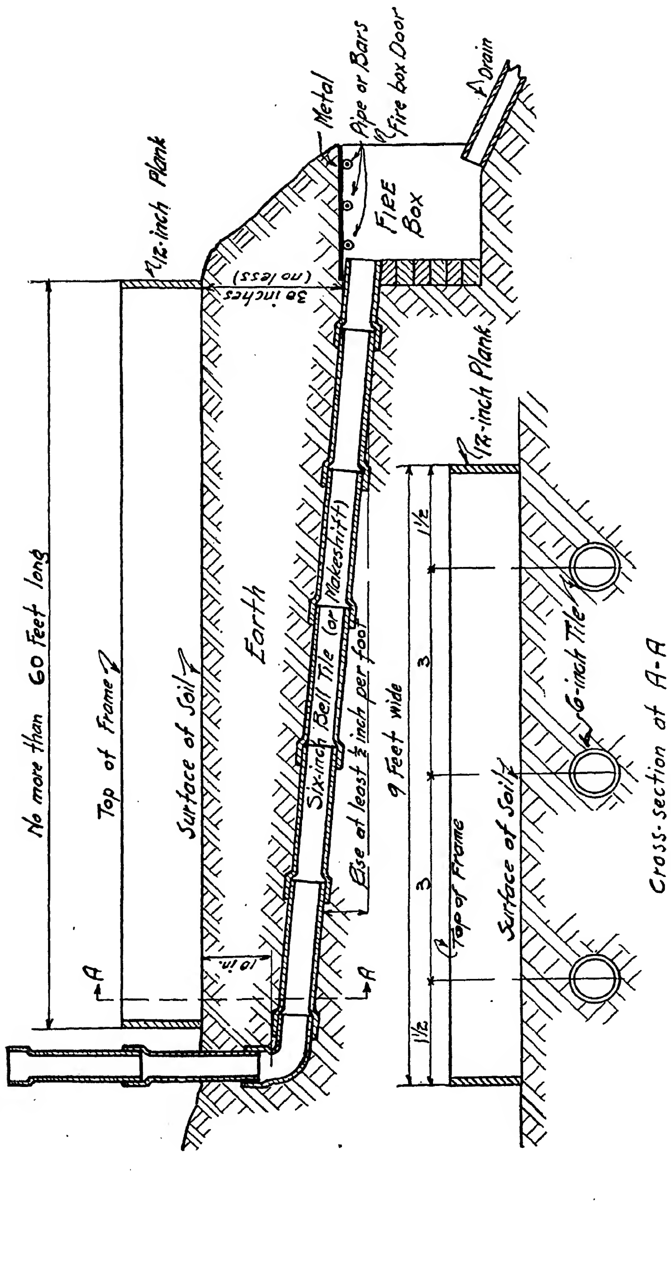


FIG. 143. Plans for a flue-heated hotbed for the production of sweet-potato plants. (*Kentucky Agricultural Extension Service.*)

beds, and with stacks at the upper end of the bed for each flue. In this manner sufficient heat is supplied to the plant bed to insure the rapid growth of plants.

It is estimated that about 10,000 plants are required for an acre of sweet potatoes. With standard-sized seed, a bushel of tubers placed in the bed, one deep with a small amount of space between each tuber, will occupy about 18 square feet. About 8 bushels of seed will be required, if placed in an unheated bed, to supply enough plants for an acre. In a well-managed flue bed, enough plants may be secured from about 4 bushels of seed.

Sweet-Potato Field Preparation, Planting, Cultivation, Harvesting, and Storing. The land is usually prepared by rather deep plowing to provide sufficient loose soil with which to make the ridges on which the crop is planted. There seem to be more advantages in ridge culture than in level culture. After the field has been plowed and harrowed, it is marked off in rows 30 to 48 inches apart, depending upon conditions. Along these marks the fertilizer is placed if it is to be used. A "ribbon" of fertilizer may be placed along the marks at the rate of 1 pound per number of feet calculated to give the desired rate per acre. The listing plow is then used to form the ridge along the rows, as marked, and over the deposit of fertilizer. These latter preparations are made some time before planting in order to give the ridges an opportunity to settle and the dry soil that may be in them an opportunity to take up moisture.

Planting may begin as soon as the danger from frost is passed. Plants are pulled very carefully from the beds, protected from wilting, and planted with the aid of a plant-setting machine or by hand methods. Stocky plants, 6 to 10 inches in length, that have been hardened while in the bed through exposure to the weather are most suitable. Plants may be spaced 12 to 18 inches in the row and are set at a depth that will leave about 3 inches of the plant above the soil. The spacing, depth, and the use of water in the transplanting process all vary in practice, depending upon conditions.

In cultivation, the sides of the ridges are scraped, the chief object being the destruction of weed growth. After the vines have extended their growth to include the middles, the trouble from weeds is almost over.

Harvesting may begin when the roots have reached marketable size. For large yields, the harvesting is usually delayed until a very short time before the first killing frosts may be expected. It is extremely important to harvest sweet potatoes in a manner that will reduce

bruising and the breaking of the skins, especially if the crop is to be put in storage. Harvesting may be accomplished by using a machine designed for the purpose, or by plowing a furrow away from one side of the ridge. The clumps are then pushed over or the ridge is pushed over by plowing under it.

Immediately after harvest, sweet potatoes should be cured if they are to be stored. Under ideal conditions, the roots should be held

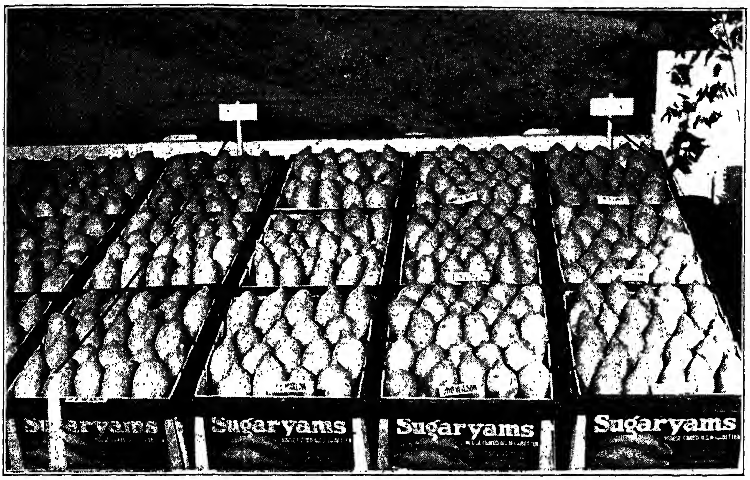


FIG. 144. The grading and packaging of sweet potatoes is a very important step in the marketing of the crop. (*South Carolina Agricultural Extension Service.*)

at temperatures ranging from about 80 to 85 degrees, under conditions of about 90 per cent relative humidity, for a period of ten days. It has been found that such a curing process hastens the healing of wounds, which is the primary objective of the practice.

After the curing, the potatoes should be held under dry storage conditions at a temperature about 50 degrees.

Insects and Diseases of Sweet Potatoes. Sweet potatoes seem to be relatively free from the attacks of insects. Some trouble may be expected from flea beetles, cutworms, wireworms, and tortoise beetles.

Black rot is a serious disease of sweet potatoes. It may be encountered in the seed bed, field, storage house, and transit. According to a California publication (120), black rot attacks the underground parts of the plant, causing yellowing of the foliage, black cankers on the stem below ground, both in the field and hotbed, and somewhat circular, depressed spots of varying sizes on the surface of

the potato, either in the ground or in storage and transit. The organism gains entrance through wounds made by mechanical injuries, by insects, or by the injury caused by a secondary root forming on the surface of the potato or on the stem.

Sweet potatoes are also affected by the stem rot, scurf, soft rot, ring rot, and a number of other diseases.

Sweet-Potato Research. Some concept of the scope and nature of the research program now in progress and the one being proposed may be gained from information adapted from Senate Document 65 (130). According to this publication, such biological investigations as the following are essential: breeding studies; studies of plant variation; control of diseases and insect pests; storage studies; dehydration investigations; development of other food products from sweet potatoes. The following refers to types of investigations pertaining to industrial utilization: agronomic-chemical investigations for the development of high starch content; studies on planting and harvesting root crops; storage for industrial utilization; preparation of sweet-potato flour for industrial use; development of low-cost, root-starch manufacturing plants; microbiological control of the starch-manufacturing process; marketing investigations.

CHAPTER XXIX

TOBACCO

Tobacco, *Nicotiana tobacum,* belongs to the Solanacae or potato family of plants. It is a vigorous annual plant with a tap root having numerous lateral branches.

The stem is round, vertical in growth habit, and ranges 4 to 8 feet in height. The leaves arise directly from the stem and are arranged alternately. The leaves vary in width but may be a foot or more wide and three feet in length. The surfaces of the leaves and stem are hairy and sticky. The stems terminate in rather prominent rose-colored or pink flowers having long corolla tubes. Tobacco is normally self-fertilized but may cross-fertilize as a result of insects carrying pollen. The seeds are very small and are borne in large capsules.

Origin and History of Tobacco. The origin of tobacco is obscure because the early Spanish explorers, landing in Mexico in 1519, found tobacco already under cultivation by the inhabitants. The Spaniards spread the culture of tobacco from Yucatan to San Domingo and to Trinidad. By 1600, tobacco was being grown in Cuba, Venezuela, and Brazil.

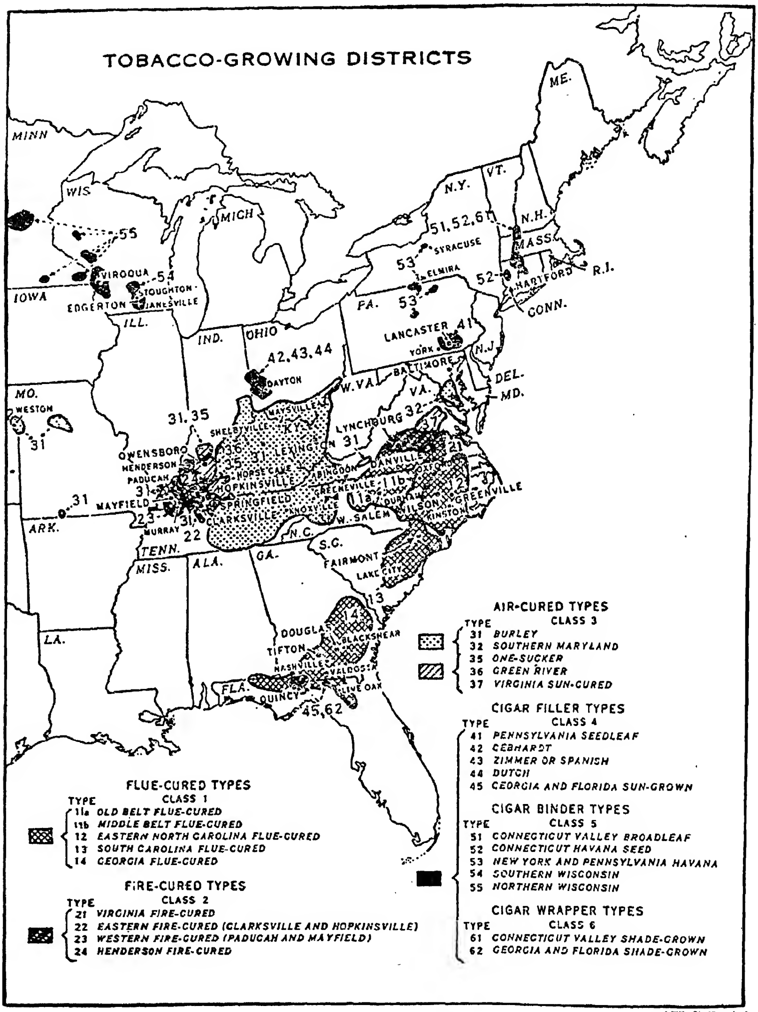
According to the 1936 Yearbook of Agriculture (176), tobacco culture was begun at Jamestown, by John Rolfe, in 1612. By the year 1616, culture of the crop had become general in the colony, and in the year 1619, 20,000 pounds of leaf were shipped to England. Nine years later the exports had increased to 500,000 pounds.

Types and Varieties of Tobacco. There are a large number of tobacco types, but a general classification into certain important groupings is to be found in Table 45.

The many types of tobacco are the result of growing the crop under different soil and climatic conditions. The natural differences brought about by these factors are accentuated by differences in cultural and curing practices. Certain localized areas have become noted for particular qualities in tobacco leaf.

The cured leaf of the dark fire-cured and air-cured types of tobacco is dark in color, high in nicotine content, and appears rather oily,

tough, and heavy. A large proportion of the dark air-cured types of tobacco is used in the manufacture of plug tobacco for chewing.



(*U.S.D.A.*)

FIG. 145.

The fire-cured dark tobacco has a characteristic odor, derived from the fuel used in curing. It is produced largely for the export trade. In this country it is used in producing plug tobacco for chewing and in making snuff.

TABLE 45 *

THE PRINCIPAL COMMERCIAL TYPES OF TOBACCO, AREAS IN WHICH THEY ARE GROWN, THEIR CHIEF USES, AND THE VARIETIES USED IN THEIR PRODUCTION

Type of Leaf	Area in Which Mainly Grown	Chief Use	Variety of Seed
Fire-cured (U. S. types 21–24)	Central Virginia, western Kentucky, and northwestern Tennessee	for export, manufacture of snuff and plug wrappers	Orinoco
Dark air-cured (U. S. types 35, 36, 37)	Immediately east of fire-cured area of Kentucky and Tennessee, and in north central Virginia	for chewing plug and export	Orinoco, One Sucker
Maryland (U. S. type 32)	Southern Maryland	for cigarettes and export	Maryland Broadleaf
Cigar wrapper, shade-grown, (U. S. types 61, 62)	Connecticut Valley and Quincy, Florida	cigar wrapper	Cuban, Florida 301, Round Tip
Cigar binder (U. S. types 51, 52, 54, 55)	Connecticut Valley, southern and southwestern Wisconsin	cigar binder	Connecticut Broadleaf, Havana Seed
Cigar filler (U. S. types 41 to 44)	Lancaster, Pa., and southwestern Ohio	cigar filler	Pennsylvania Seedleaf, Ohio Seedleaf, Zimmer Spanish, Little Dutch
Flue-cured (U.S. types 11 to 14)	Southern Virginia, northern and eastern North Carolina, eastern South Carolina, southern Georgia, northern Florida	cigarette, pipe, and chewing tobaccos, and for export	Orinoco
Burley (U. S. type 31)	Central and northern Kentucky, southeastern Indiana, southern Ohio, western West Virginia, eastern and central Tennessee, western North Carolina, western Virginia	cigarette, pipe, and chewing tobaccos	White Burley

* United States Department of Agriculture, Yearbook of Agriculture, 1936.

The cured leaf of the Maryland type of tobacco is slightly thin, light in weight, dry rather than oily, and light reddish-brown in color. It has a mild aroma and has excellent burning qualities. Much of

the Maryland tobacco has been produced for export, but at the present time the better grades are used in this country in the manufacture of blended cigarettes.

Cigar-leaf tobacco is of three types: cigar filler, cigar binder, and cigar wrapper. The tobacco that is used for the core or filler of cigars is grown chiefly in Lancaster County, Pennsylvania, and the southwestern Miami Valley section of Ohio. Tobacco grown in the Connecticut Valley (not under shade) and in southern and southwestern Wisconsin is used as binder leaf to hold the filler or core of the cigar. The tobacco used to wrap cigars is grown under shade near Quincy, Florida, and in the Connecticut Valley.

Flue-cured or bright tobacco is cured by artificial heat. This is a rapid process of curing in which heat is applied to the tobacco by a system of flues or pipes. The leaf does not come in contact with the smoke from the fuel. The cured leaf has a bright lemon to orange color, a distinctive aroma, and a high sugar content. It is grown and cured in southern Virginia, northern and eastern North Carolina, eastern South Carolina, southern Georgia, and northern Florida. Flue-cured tobacco is used in the manufacture of cigarettes, pipe tobacco, and plug tobacco for chewing.

Burley is a distinct type of tobacco used in the manufacture of blended cigarette, pipe, and chewing tobacco. Burley is grown in certain areas of Kentucky, West Virginia, Ohio, Indiana, Tennessee, Virginia, and North Carolina.

Tobacco-Production Statistics. The amount of tobacco production in the United States is indicated by the information presented in Table 46.

The leading states in tobacco production for the year 1937, with their acreages, were: North Carolina, 684,000; Kentucky, 411,500; Virginia, 148,000; Tennessee, 137,500; and South Carolina, 112,000.

Tobacco-Production Factors and Practices. It is the variation in the soil, climatic conditions, and production practices which are largely responsible for the differences in the tobacco-leaf types. For this reason, the following information covers many variations relating to tobacco production.

Tobacco Plant Beds. Tobacco as it appears growing in the field has been transplanted. The plants for transplanting purposes are grown in plant beds. Sometimes hotbeds or cold frames are used, but the usual practice is to cover a bed, 6, 9, or 12 feet in width, having sufficient length to supply the plants for the acreage being

TABLE 46 *

TOBACCO: ACREAGE, PRODUCTION AND VALUE 1934 TO 1940

Year	Acreage Harvested	Average Yield per Acre	Production	Season Average Price per Pound Received by Farmers	Farm Value
	(Acres)	(Pounds)	(1000 pounds)	(Cents)	($1000)
1934	1,278,500	846.0	1,081,629	21.3	224,699
1935	1,437,100	902.6	1,297,155	18.4	238,382
1936	1,438,300	803.3	1,155,328	23.6	272,895
1937	1,750,600	892.8	1,562,886	20.4	319,465
1938	1,599,300	860.3	1,375,823	19.7	269,184
1939	2,004,700	935.0	1,874,407	15.4	288,171
1940	1,404,350	1,033.9	1,451,966	15.8	228,891

* United States Department of Agriculture, Agricultural Statistics, 1941.

planted, with cotton cloth often called *tobacco canvas.* The beds are usually surrounded with 6- to 10-inch planks, to which the canvas is fastened after the bed has been prepared and seeded.

According to the Ohio Station (9), permanent plant beds are being used with increasing frequency in the Miami Valley tobacco section. The beds are steamed to control diseases and weeds; and sand, corn stalks, and peat moss have been found useful in adapting the soil conditions in the plant beds to plant production.

Instead of using permanent plant beds, tobacco growers often select new locations each year. It is essential to select soil that is fertile, well supplied with humus, well drained, and friable, and that has a southern or eastern exposure to promote an early season warming of the soil.

In some sections, plant beds are sterilized by burning brush over the extent of the bed until the soil has been thoroughly heated to a depth of 3 or 4 inches. After such burning, the bed is raked over and cleaned to form a fine seed bed. Another common method is to use a steam pan which is inverted over one section of the bed after another until the whole bed has been sterilized. Ohio investigations (9) indicate that 25 minutes of steaming at a pressure of 125 pounds, or 20 minutes at 150 pounds', pressure will penetrate into a well-conditioned plant bed sufficiently to destroy disease organisms and weed seeds. It is very important to use sanitary measures after sterilization to prevent the introduction of diseases.

When needed, the plant beds should be fertilized. From 20 to 80 pounds of a 3–8–6 commercial fertilizer per 1000 square feet may be used.

The recommendations as to size of plant beds to provide plants for an acre of tobacco vary from 100 to 450 square feet. Local experience and practices obviously must be followed in determining the plans to use in a specific situation.

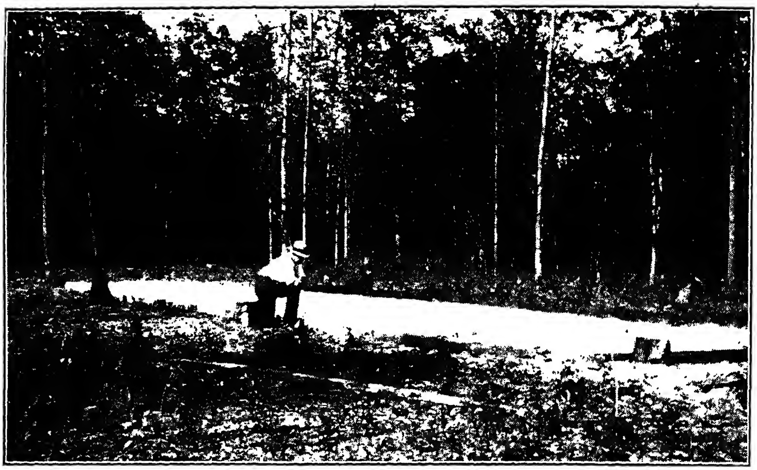


Fig. 146. Rich soil that is well supplied with decayed organic matter should be selected for a tobacco plant bed. This bed is covered with tobacco canvas. (*Tennessee Agricultural Extension Service.*)

A level teaspoonful of seed is required for each 100 square feet of plant bed. The seed may be scattered uniformly by thoroughly mixing the seed with ashes or some other material of a similar nature, spreading the material over the bed and raking until an even distribution seems assured. The beds are then lightly rolled or tramped and the tobacco canvas placed over the bed.

After the plant beds have been seeded, the beds are watered, weeded if necessary, and otherwise cared for until the time arrives for pulling the plants for transplanting purposes. A few days previous to pulling the plants, the tobacco-canvas covers are removed in order to harden or toughen the plants, preparatory to transplanting.

Field Preparation and Rotation. Fields for tobacco production are plowed in the fall or early spring. It is essential to cultivate the soil in a manner to destroy weed growth before the time of setting the plants.

It has been found advantageous to grow tobacco in rotation. A rotation, used in Ohio (9), consists of tobacco, wheat, and clover. In North Carolina (47), it is recommended that burley tobacco be grown after a grass sod in a three- or four-year rotation. In Tennessee (104), it is recommended that burley tobacco be grown on a deep, well-drained soil, rich in humus, and that it is preferable to have the tobacco follow a bluegrass sod.

Transplanting, Fertilizing, and Cultivating Tobacco. The plants grown in the plant bed should be in the neighborhood of 6 inches in height to be suitable for transplanting purposes. The time of transplanting varies. In the Miami Valley district of Ohio (9), the best yields have been obtained by setting plants about June 20.

Many local factors must be considered in connection with the number of plants to set per acre. The rows may vary from 3 to 4 feet in width and plants may be set from 12 to 30 inches in the row.

From 600 to 1000 pounds of 3–8–5 fertilizer are commonly used for tobacco in the states of Florida, Georgia, North Carolina, and South Carolina. In Indiana, about 200 pounds of a 2–12–6 are commonly used, 800 pounds of 4–8–12 in Maryland, and 750 pounds of 4–8–7 in Pennsylvania.

Various methods of applying fertilizer to tobacco are presented in Table 47. The most suitable method for securing satisfactory results from the use of fertilizer is that of placing the fertilizer in bands along the sides of the plants. Under certain conditions this method, coupled with a side dressing later in the season, has produced superior results.

TABLE 47

YIELD FROM SIDE PLACEMENT COMPARED WITH THAT FROM OTHER METHODS OF APPLYING FERTILIZER TO TOBACCO *

Method of Application	Average Yield per Acre	Value per Acre
	(Pounds)	(Dollars)
Drilled in row, mixed and ridged †	1422	277
Mixed with soil around plant	1214	235
Bands $2\frac{1}{2}$ inches on both sides and 1 inch below root crown	1523	307
Three-fifths at side at planting, two-fifths as side dressing later	1544	320

* Average results from experiments at Oxford, N. C., Florence, S. C., and Tifton, Ga., in 1935, and at Upper Marlboro, Md., in 1934. Taken from the Yearbook of Agriculture, 1938.

† Prevailing method on farms.

At the Ohio Station (9), it has been found that liberal applications of phosphoric acid, supplemented with nitrogen and potash, have been profitable. Row applications of fertilizer were found to be more satisfactory than broadcasting the material. Profitable increases in yield were obtained from the use of side dressings with nitrogen in a quickly available form, applied when the plants had a spread of 6 to 8 inches.

In tobacco production, cultivation to kill weeds and break soil crusts is essential. If weeds or grass begin to grow between the plants in the row, the hand hoe should be used sufficiently often to eradicate the growth.

Topping and Suckering Tobacco. When tobacco plants in the field have flower buds in the early pink stage, it is customary to break off (top) the stem with the flower buds, leaving a number of leaves. The topping results in a broadening growth of the leaves and an increase in the quality.

Topped plants develop suckers from buds in the axils of some of the leaves. It is important to remove the suckers from the plants at least once, and experience indicates that the quality and yield of tobacco may be improved by removing all sucker growth.

Harvesting Tobacco. Tobacco is usually harvested when the central leaves on the plant have reached maturity. At this time the top leaves will still be green while the lower leaves will have been matured for a time. Leaves show maturity when they have changed from a dark-green to a lighter green color and have developed a mottled appearance.

Tobacco leaves are harvested sometimes by pulling or stripping them from the standing stalks. The leaves are then strung up by various methods in curing houses. The most common method of harvesting is to cut the plants close to the ground with a hand chopper or "tobacco axe." The cut plants are allowed to wilt for a time, after which the plants are placed in small piles. The plants in these piles are immediately strung on laths or sticks. This is sometimes accomplished by splitting the main stem of the plant for some distance and hanging the plant astride a lath or stick. More often a lath holder is employed which has a socket that will hold a lath in a horizontal position. A spearhead is placed over the end of the lath, and plants are strung on the lath by spearing the plants near the butt ends. The strung tobacco plants are then placed on a wagon that is equipped with a rack to carry the plants strung on the laths. The

crop is hauled to curing houses or sheds equipped with a suitable means of hanging the plants for curing.

Flue-cured tobacco is harvested by pulling the bottom leaves as soon as they are mature. The leaves are looped in small bundles composed of about three leaves each. Twenty-six to thirty bundles are placed on a 4½-foot stick. The sticks are then hung in the curing house.

Curing Tobacco. Air-cured tobacco is hung in sheds equipped with ventilators which are used to control, to some extent, the temperature, air circulation, and humidity within the curing sheds.

Fire curing of tobacco is accomplished by burning slow fires on the floor of the curing house. The smoke and heat from the fires play an important part in the curing process. The process of curing occupies in the neighborhood of ten days.

The process of flue-curing tobacco is the most complicated. Curing barns have furnacelike equipment, with long flues extending through the structure to distribute heat to the tobacco hung for curing.

As described in a North Carolina publication (47), a fire is started as soon as the tobacco is hung in the curing house. A temperature about 85 to 100 degrees Fahrenheit is maintained until the leaf is rather yellow. The time required varies from 24 to 36 hours. The next step is to raise the temperature at the rate of 4 to 5 degrees per hour until it has reached 120 to 125 degrees Fahrenheit. This temperature is held until the tips of the leaves become dry. The tobacco should have a pale-yellow color at this time. Next, the temperature is raised at the rate of 4 to 6 degrees per hour until a temperature of 135 to 140 degrees is reached, which temperature is held until the leaves are dry in all parts of the curing house. It requires from 84 to 96 hours to complete the curing of tobacco by this process.

When the curing is completed, the heat is withdrawn and the doors of the curing house are opened. As soon as the tobacco leaves have taken on enough moisture (arrived in "case" or "order") to prevent the breaking of the leaves, the tobacco is removed from the curing house. During the rush season the curing house is filled, and it is emptied each week during the curing season.

Stripping and Sorting Tobacco. There are many details pertaining to the stripping and grading of tobacco which vary with the type of tobacco. Before stripping can commence, the tobacco leaves must be in "case" or "order," that is, contain enough moisture to prevent the breaking of the leaves when handled. Tobacco leaves may take

up enough moisture from the air if weather conditions are right to be in "case," or it may be necessary to supply moisture by some artificial means.

The stripping and sorting process consists of stripping the leaves from the tobacco stalk, sorting the leaves into various grades, and tying a number of leaves of the same grade into "hands" or bundles. The tobacco may go to market in the form of such bundles, or the leaves may be placed in large packing boxes in preparation for market.

Tobacco Insects. A number of insects are injurious to the tobacco crop.

Tobacco Hornworm. This is a large worm, ordinarily called the tobacco worm, which devours the leaves of the plant. It is common practice to pick the worms from the plants or to watch for and destroy them while engaging in hoeing, topping, or suckering. The worm may be destroyed by dusting the plants with such poisons as lead arsenate or Paris green.

Cutworms. Various types of cutworms are troublesome both in the plant beds and in the field. Plant beds may be dusted with lead arsenate, whereas poison baits may be useful under field conditions in controlling the worms.

Wireworms. Wireworms are the larvae of the click beetle. The worms tunnel in the stems of the plants, and frequently injury is serious enough to destroy the young plants soon after they are set in the field. Wireworms are most often troublesome in connection with early set crops and with lands previously in sod. The avoidance of such sod lands, the use of vigorous large plants in setting, and the late setting of plants may be useful in avoiding damage from wireworms.

Flea Beetles. Flea beetles are especially troublesome in plant beds where they injure the plants by sucking the sap. Control may be gained by dusting with barium fluosilicate.

Grasshoppers. Tobacco is also injured by grasshoppers. This damage is difficult to control. Sometimes it is recommended that the outside rows of a field be thoroughly dusted with a poison.

Tobacco Diseases. Tobacco is injured by a number of diseases which, under certain conditions, greatly reduce or even destroy the entire value of the crop.

Black Root Rot. This disease is a soil-borne fungus which attacks the roots of the tobacco crop. The disease is controlled by using root-rot-resistant varieties.

Mosaic. Mosaic is a virus disease, attacking tobacco. It produces a rough, mottled condition of the leaves. Plants thus affected produce an inferior grade of leaf so far as marketing is concerned. The chief method of controlling mosaic in tobacco is the one of avoiding infection. The plants afflicted should be removed from the field as soon as discovered. It has been demonstrated that workers, using natural leaf during the time of working about plant beds or in tobacco fields, spread mosaic infection if the tobacco they happen to be

Fig. 147. The row of tobacco in the center of the picture is nonresistant to root rot. The tobacco plants in the adjacent rows are highly resistant to the disease. (*Kentucky Agricultural Experiment Station*.)

using is infected. These workers should use tobacco which has been through a manufacturing process, because it has been found that mosaic is destroyed thereby. It is also recommended, in the control of mosaic, that plant beds be burned or steamed and that all tobacco refuse or trash be kept away from beds and fields.

Blackfire or Angular Leaf Spot. Blackfire is a bacterial disease of tobacco which is most evident when the plants are about ready for transplanting. Small, angular, dark-brown or black spots are to be observed on the leaves. Such spots become larger and destroy the normal leaf tissue as the plant grows. Infected plants should not be transplanted to fields. The control rests primarily in selecting clean seed and in using various sanitary measures in connection with plant beds and fields.

Wildfire. Wildfire is a disease which is often mistaken for blackfire. It occurs in the plant beds. The spots on the leaves, instead

of being angular as is true of blackfire, tend to be round with a small, brown center. Wildfire is controlled in the same manner as blackfire.

Other Diseases of Tobacco. Tobacco plants while in the plant beds are sometimes attacked by a disease called *blue mold. Brown root rot* is a disease which attacks the roots of tobacco plants in a manner similar to black root rot. *Fusarium wilt* is another disease

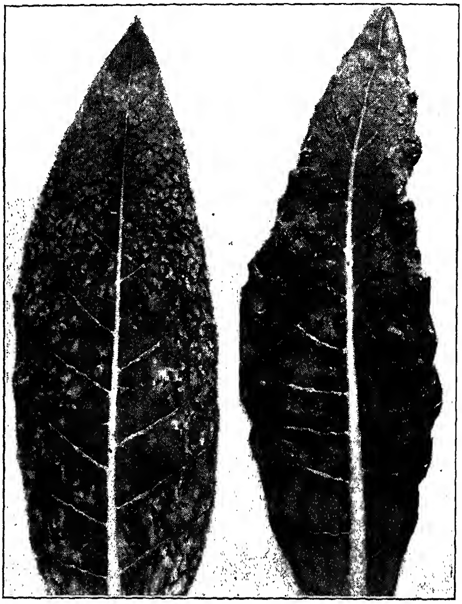


Fig. 148. These leaves of tobacco are infected with mosaic which is a serious virus disease of this crop. (*Kentucky Agricultural Experiment Station.*)

which seems to attack tobacco when grown on light soils along streams. Resistant varieties have been developed.

Tobacco Research. The possibilities for research in connection with tobacco are numerous. The present research pertains to plant-breeding studies having numerous objectives, agronomic research, pathological investigations, chemical research, studies of curing, grading, and with the many aspects of by-product uses. Senate Document 65 (130) lists in detail the many items of present and proposed research with tobacco. The information from this bulletin is as follows.

Present research in the United States on tobaccos falls broadly into four The first group of studies is concerned with leaf tobacco for smok-

ing or other human consumption; the second with other uses to which tobacco may be put, which may be described as byproduct uses; the third with the production of tobacco especially for nicotine; and the fourth with economic studies. In the outline of present research which follows, the investigations considered here are classified under the first three groups, briefly described as research on leaf tobacco, research on byproduct uses, and the production of tobacco for nicotine.

Leaf Tobacco—*Breeding*

Plant-breeding studies are being widely conducted with the following objectives.

1. Improving growth characteristics, quality, and yield in standard and hybrid strains of all types.

2. Development of strains that are resistant to the following diseases: Mosaic; black root rot; brown root rot; black shank; Granville wilt; fusarium wilt; downy mildew; wildfire; and angular leaf spot.

3. Development of strains of the *tobacum* species that possess a low nicotine content.

4. Development of strains and hybrids of the *rustica* species that possess a high nicotine content.

5. Development of strains of the Turkish types of tobacco adapted to American conditions.

6. The above work is being supplemented by broad studies of the genetics, taxonomy, and cytology of the genus *Nicotiana*.

Agronomic Research

7. Biochemical studies of several important tobacco types in several of the tobacco-producing areas. These bear upon the nutritional and environmental factors in relation to the plant responses, including the effects upon combustibility, aroma, nicotine content, and other elements of quality.

8. Studies of the effects of cropping and soil management practices, including the effects of rotation, cover crops, and natural vegetation upon the yield and quality of tobacco.

9. Studies of the effects of rainfall and of irrigation methods upon the yield and quality of tobacco.

10. Experiments upon the structural responses induced by varying the distance of planting, height of topping, and extent of suckering as they affect quality and yield.

11. Fertilizer studies to determine nutritional requirements with reference to quality, yield, and resistance to disease for all tobacco types.

12. Studies on the adaptability of various soil types to the production of flue-cured tobacco.

Pathological Investigations

13. A study of the mosaic disease of tobacco as regards its effect upon yield and quality and methods for its control.

14. Fundamental researches on tobacco mosaic as a basis of approach to the broader general subject of filterable viruses and their function in plant and animal physiology.

15. Researches on nematodes and methods for their control by chemical and agronomic means.

16. Studies of the taxonomy, distribution, and control of the organisms causing tobacco diseases, including black root rot, brown root rot, black shank, Granville wilt, fusarium wilt, wildfire, angular leaf spot, frog eye, downy mildew, etc. The methods of control include sanitation, rotation practices, chemical methods, etc.

17. Methods for control of downy mildew in the seed bed by fumigation with benzol, paradichlorobenzene, and other hydrocarbons, and also by means of chemical sprays.

18. Studies of the transmission of tobacco diseases through manufactured tobaccos.

19. Studies of organisms which cause deterioration of tobacco in the curing barn, and of methods for their control.

Entomological Research

20. Studies of insects attacking the growing tobacco plant, and development of means for their control.

21. Studies to develop measures for eliminating, or reducing to a minimum, insects which attack tobacco in storage and in the growers' packhouses.

Chemical Research

22. Determination of the physical characteristics, chemical composition, and smoking qualities of the several types of flue-cured tobaccos, as influenced by soil, weather factors, and liming.

23. Studies of the role of nitrogen, potash, phosphorus, sulphur, chlorine, magnesium, and the trace elements, including manganese, boron, iron, and copper, in the nutrition of the tobacco plant.

24. Studies of the chemical changes occurring during the growth, curing, and storage of tobaccos.

25. Chemical studies of tobacco smoke and the use of smoke data in devising methods for the treatment and proper blending of leaf tobacco.

26. Studies of factors influencing the burning quality of tobacco.

27. Effect of degree of maturity of tobacco at harvest on its chemical composition and smoking qualities.

28. Correlation of stalk positions of the leaf and smoking quality of tobacco.

29. Investigation of flavors in tobacco.

30. Effect of various processing operations on the chemical composition of leaf tobacco. This includes the correlation of chemical composition and physical characteristics with tobacco quality in the endeavor to improve manufactured products.

31. Fermentation studies on cigar tobacco.

Curing

32. Biochemical investigations of the curing processes of flue-cured, burley, fire-cured, cigar, and Maryland tobaccos.

33. Investigations concerning the relative practicability of coal, fuel oil, and electricity as a source of heat in flue curing.

34. Supplemental application of atomized water in the curing process for fired tobaccos.

35. Application of artificial heat in the curing of air-cured types.

Grading

36. Studies of the factors that determine quality and grade of tobacco.

37. Establishment of standards for tobacco grades.

By-Product Uses—Nicotine

38. Development of new applications of nicotine in insect control.

39. Investigation of fixed nicotine compounds as stomach poisons for codling-moth larvae (apple worms). These compounds include nicotine-bentonite, nicotine-peat, etc.

40. Use of nicotine tannate for the control of the corn earworm.

41. Control of the adult codling moth and other orchard and field pests by methods based upon the vaporization of liquid nicotine. This includes chemical and engineering studies of methods for vaporizing and applying nicotine as a fumigant.

42. The use of nicotine compounds for the control of external and internal parasites of poultry and other livestock.

43. Development of activators for nicotine to permit the use of lower concentrations, and thus lower the cost of application when used as a contact insecticide.

44. Studies on the use of new carriers and diluents for nicotine; for example, the use of finely ground tobacco fortified with commercial nicotine extract and carrying larvicidal oils.

45. Development of chemical methods for determining the small amounts of nicotine in spray deposits.

By-Products Other Than Nicotine

46. Use of denicotinized tobacco extract as an emulsifying agent for insecticides and in industrial products.

47. Use of ground tobacco as a conditioner in phosphate fertilizer to prevent caking.

48. Research on methods of recovering organic acids and potash from tobacco stems.

49. Use of low-grade tobacco as a source of organic material and fertilizer elements in certain soil-management practices.

50. Studies of the occurrence of alkaloids other than nicotine in various species of *Nicotiana*.

51. Studies on denicotinized tobacco extract. This material has been found to be a very efficient blood coagulant and shows promise in the field of medicine.

52. Studies on nicotine acid. This acid can be made from nicotine and apparently has specific therapeutic properties in the curing of pellagra in man and black tongue in dog.

53. Production of tobacco for nicotine. In addition to the utilization of surplus and off-grade tobaccos, and tobacco wastes as outlined above, breeding experiments, coupled with soil, environmental, and cultural studies for the production of high-nicotine tobaccos with high yields per acre, are under way. This work is being done with various species in pure lines and species crosses, and is being carried on in regions outside of established tobacco-growing areas, including California and Oregon. The aim is to produce new nonsmoking tobaccos, specifically for industrial uses.

CHAPTER XXX

BUCKWHEAT, FLAX, RAPE, RICE, AND SUNFLOWERS

BUCKWHEAT

Buckwheat, *Fagopyrum vulgare,* is of the Polygonaceae or buckwheat family of plants. It is an annual plant 2 to 4 feet in height. Buckwheat is utilized frequently as an emergency crop to be grown where other crops have failed. It is one of the shortest seasoned grain crops, maturing in sixty to eighty days. Buckwheat is valuable as a grain crop, honey crop, green-manuring crop, and as a cover crop. It is adapted to a wide variety of soils and climatic conditions.

History and Importance of Buckwheat. Buckwheat is of ancient Chinese origin, being unknown in European countries before the fifteenth century.

The average annual production of buckwheat in the United States for the period 1927 to 1936 was 8,569,000 bushels. In the year 1938, 6,682,000 bushels were produced in the United States. Of this amount New York produced 2,496,000 bushels, Pennsylvania, 2,170,000, followed by West Virginia, with a production of 256,000 bushels, and Michigan, with a production of 243,000 bushels. Many other states produce small amounts of buckwheat.

Varieties of Buckwheat. The Japanese, Silver Hull, and Gray are the leading varieties of buckwheat commonly grown. The Japanese is the largest growing type and produces a larger seed than the Silver Hull or Gray. The seed of Japanese buckwheat is black. This variety gives the highest yields under good conditions.

The Silver Hull has a smaller seed and the plant is considerably smaller than the Japanese. This variety is shorter seasoned and is not affected quite so much as the Japanese variety by extremely hot, dry weather, which causes "blasting" of buckwheat flowers. The Gray is very similar to the Silver Hull.

Many growers mix the Japanese with either the Gray or the Silver Hull, and claim that larger yields result during adverse seasons.

Buckwheat seeds should be whole, plump, free from mixture with weed seeds, and of good odor and high germination.

Preparation of Seed Bed for Buckwheat. Buckwheat is usually planted after a failure of corn, beans, beets, or other early planted crop. Little attention is commonly given to refitting the seed bed, but it will pay to disc the land thoroughly and to work with harrow and cultipacker before reseeding to buckwheat. This crop is also planted on poorly prepared seed beds, which cannot be brought into proper condition to receive other cultivated crops. Although buckwheat will give a good account of itself under these conditions, best yields are secured by plowing and fitting the seed bed as for oats or barley.

Fertilizer is seldom applied to buckwheat, but superphosphate at the rate of 250 pounds, or a dressing of manure, or both, will give great increase in the yield of buckwheat.

Planting. Buckwheat should be planted when the seed bed is well warmed. The seed of buckwheat will start on comparatively hot, dry seed beds under conditions where common field seeds fail to germinate. The crop may be planted as late as the first of July in the Northern States or the middle of July in Corn Belt States, but larger yields are secured by planting in May or early June. For green-manuring purposes, or to prevent erosion in orchards or on hillsides, or if used as a companion crop with summer seedings of alfalfa on light soils, buckwheat may be seeded in late July or early August. It is usual to plant 2 to 5 pecks per acre, 3 pecks being the average rate. The seed should be planted at a depth of 1 or 2 inches.

Harvesting. Buckwheat is intermittent in its ripening period; that is, all the blooms do not ripen into seed at the same time. Judgment should be used in cutting the crop for curing at the time when most of the seeds are ripe and when large loss will not occur from shattering. Buckwheat is usually ready to harvest sixty to eighty days after planting. A mower with buncher attachment, binder, or cradle is usually employed. Do not cut when the crop is dry; as far as possible, do the work of cutting the crop in the early morning or on damp days, to prevent shattering.

Curing and Threshing. Buckwheat should be cured in small, uncapped shocks. The stems and seeds carry an unusual amount of moisture; hence capping results in loss from mildewing. After curing for several days or a week or more in the field, the crop is ready for threshing. If the ordinary grain separator is used, the crop should be hauled in from the field in the early morning and stacked for

threshing in order to prevent the great loss of buckwheat grain which would occur if the grain were stacked when very dry, in midday or in the afternoon.

FLAX

Common flax, *Linum usitatissimum,* is of the Linaceae or flax family of plants. Flax is grown chiefly for seed purposes in the United States and Canada. It is usually the first crop grown on newly turned sod lands in the Northwestern States and in western Canada.

The production of seed flax is of greatest importance in Minnesota, North and South Dakota, and adjoining areas of neighboring states. During recent years seed-flax growing has increased extensively in the Imperial Valley of Southern California. The production of fiber flax is limited to several thousand acres in Oregon, in eastern Michigan and Ontario, and in Canada. The seed is used in making linseed oil and oil feed, and the fiber flax in the manufacture of linen thread and tow. Flax "hurds," or the straw remaining after the seed is threshed, is used as a roughage and to some extent in making coarse tow for toweling, bagging paper, and rugs, and insulating material for buildings.

Production statistics indicate that the average annual production of flax in the United States, for the period 1927 to 1936, was 13,751,000 bushels. In the year 1938, the production was 8,171,000 bushels.

Flaxseed. Great losses are caused by the wilt. This disease is controlled by planting wilt-resistant varieties, lately produced by experiment station plant breeders in flaxseed-producing states, and by treating seed with formaldehyde, and growing flax on newly turned land or in a long rotation which brings flax on the land every seven or eight years.

Seed-Bed Preparation. Plowing should be done in early spring or fall. Flax is usually planted on the first breaking of new ground. It will give a comparatively good yield on fresh-turned sods, plowed to shallow depth, but best yields are secured by preparing a seed bed in the same way that ground is fitted for oats or barley.

Planting. Early plantings give best yields. Late plantings suffer loss in yield, owing to the plants' being subjected to the hot weather of summer during the early stages of growth. Usually two pecks of seed per acre are drilled with an ordinary grain drill.

Harvesting. Flax is harvested for seed when the seed balls are brown and the eight or ten flax seeds in each are well developed. The

grain binder is used in harvesting and the flax is cured in open shocks, or under favorable conditions it is threshed immediately.

Fiber Flax and Linseed Flax for Fiber. The following information, selected from Senate Document 65 (130), provides information pertaining to the use of flax as fiber.

Fiber Flax

About 40 million dollars' worth of linen and 2 to 3 million dollars' worth of fiber are imported annually into this country. Only about $200,000 worth of fiber is raised here. The tall nonbranching variety of flax cultivated for fiber will grow in many parts of the country, but about 80 per cent of that grown here is produced in Oregon, where its cultivation on 5000 acres is sponsored by the State flax commission. If imports of flax fiber and linen were eliminated and if our domestic demand for linen continued at present levels, it would take 125,000 acres to raise enough flax fiber to supply these domestic requirements. With crop rotation, about 500,000 acres of suitable land would be necessary. This acreage is available in the Willamette Valley in Oregon. The Oregon linen fiber now amounts to about 400 to 500 tons annually. It is of good quality and is used largely for the manufacture of linen thread and twine.

The average yield of flax in Oregon is about 1.65 tons per acre. From this are obtained 230 to 300 pounds of linen fiber and 100 to 130 pounds of tow and pullings ready for spinning, 250 pounds of stock feed, 500 to 600 pounds of seed, and a residue of shive. The flax is pulled mechanically and retted by bacteria. The fiber is obtained by mechanical scutching and hackling. For further development the industry needs scientific research to lower the processing cost and to devise uses for the byproducts, such as the shives which are now used for fuel.

Linseed Flax for Fiber

The variety of flax raised for its seed is generally a short, many-branched plant bearing a considerable quantity of seed. It is unsuited for the production of a long linen fiber such as is obtained from fiber flax. This variety of flax is allowed to come to maturity in order to obtain the largest yield of seed, and this tends to toughen the woody part of the plant so that the bast fiber is more difficult to obtain.

The linseed-flax straw fiber is mainly a wasted byproduct of the seed-flax industry, and the amount of flax straw available varies directly with the quantity of flaxseed produced. It is difficult to estimate accurately the quantity of fiber annually available. However, the straw-to-seed ratio is approximately 2 to 1, and about 80 per cent of the flax is raised in concentrated areas, so that it is easily accessible to markets. The crude bast fiber content of the straw ranges up to about 20 per cent. Based on these figures the quantity of fiber available annually in the last 20 years has varied from

FIG. 149. The hand method of pulling fiber flax is giving way to harvesting by means of tractor-drawn mechanical pullers. (*Oregon Agricultural Experiment Station.*)

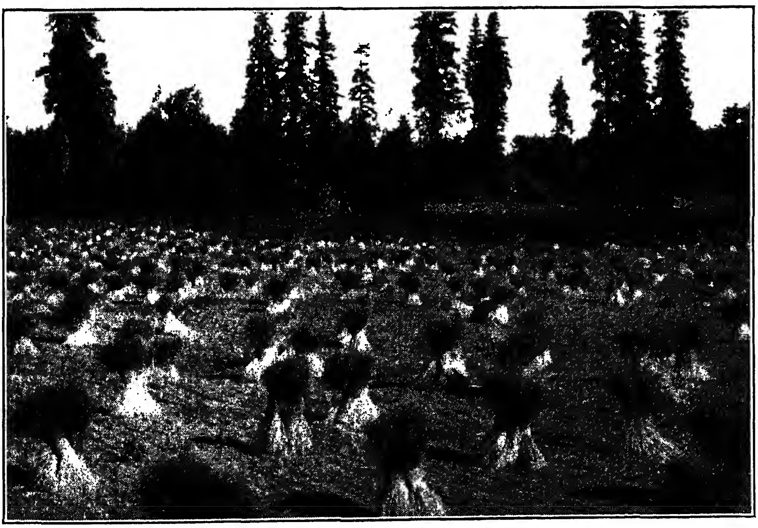


FIG. 150. After fiber flax has been pulled, it is set in small shocks to dry. (*Oregon Agricultural Experiment Station.*)

about 275,000 tons in 1924 to about 50,000 tons in 1936. The average quantity of fiber available annually for the 10 years ending in 1930 was approximately 170,000 tons. However, since that time the quantity of fiber available has fallen off to an average of 80,000 tons annually, for reasons that are discussed in the section on flaxseed.

Small quantities of flax straw are now used commercially for tow making, paper, and semiflexible sheets for insulation, but the demand is less now than in former years. There is also a well-developed industry based on the manufacture of flax-straw rugs. Commercial utilization of flax straw in 1924 amounted to about 200,000 tons (fiber equivalent, 40,000 tons) but in 1937 was only about 10,000 tons (fiber equivalent, 2000 tons). Therefore, at the present time there is being wasted about 97 per cent of the flax fiber available, or approximately 75,000 tons. However, because of inaccessibility to markets, presence of weeds in the straw, and other undesirable factors that affect the straw value, it is believed that it would be more conservative to calculate only half this tonnage as actually available for possible utilization.

Although this fiber is not as long or as strong as the fiber generally used for linen, it is a useful material, and if it can be obtained cheaply enough it may be used for coarse linen cloth, for rugs, or in the manufacture of cigarette paper; it is particularly suitable for the latter use because of the special characteristics of the fiber. About 5 to 6 million dollars' worth of cigarette paper is imported annually.

Linseed fiber is, then, a potential source of supply for a very large amount of useful fiber. This raw material is now mostly wasted.

RAPE

Brassica napus or rape belongs to the Cruciferae or mustard family of plants. There are both annual and biennial varieties of rape. Dwarf Essex rape is the variety which is used to the greatest extent. The crop is used primarily as a pasture or forage crop.

Rape is particularly adapted to cool moist climates in the northern part of the United States. It requires a rich soil for satisfactory yields.

Rape may be seeded in rows about 2 to 2½ feet apart so that it may be cultivated. From 2 to 3 pounds of seed per acre are required. Another method is to drill the seed at the rate of 4 to 8 pounds per acre with small grain. After the grain has been harvested the rape develops into a pasture crop. Sometimes rape is seeded at the rate of 3 to 5 pounds per acre at the time of the last cultivation of corn. The corn and rape are then hogged off or the combination may be used for sheep.

RICE

Oryza sativa is the common cultivated form of rice grown in the United States. It is an annual plant which grows under very moist conditions. The average annual production of rice in this country for the period 1927 to 1936 was 42,500,000 bushels. In the year 1938, the production was 52,303,000 bushels, of which 20,748,000 bushels were produced in Louisiana, 13,005,000 bushels in Texas, 9,450,000 bushels in Arkansas, and 9,100,000 bushels in California.

Rice is used primarily as a food grain. About 2,000,000 bushels are used annually in the manufacture of fermented malt beverages.

Land to be devoted to rice is plowed either in the spring or fall. The seed bed is prepared in a manner similar to other cereal crops. From 1 to 2 bushels of seed per acre may be drilled or broadcasted from the middle of April to the last of May.

When the plants have grown to a height of about 6 inches, the rice field is flooded to a depth of 1 or 2 inches. As the plants grow, the depth of water is increased until a depth of about 5 inches is attained, when the rice plants are about 2 feet in height. The water level is retained until the crop begins to ripen, at which time the water is drawn off to permit harvesting.

The ordinary grain binder is used in harvesting, and the crop is shocked and cured in a manner similar to the grain crops. Cutting should commence somewhat prior to maturity.

SUNFLOWERS

Sunflowers, *Helianthus annuus,* are grown in a limited extent for the making of silage and in some instances for seed to be used as a poultry feed.

The cultivated sunflower is an annual plant with strong, erect stems. The stems, which vary from 1 to 3 inches in diameter, reach a height of 5 to 15 or more feet. The plant produces a broad, flat head or flower which, when mature, contains a large number of seeds.

Sunflowers are best adapted to those regions in the Northern States where the climate prevents corn growth sufficient for an adequate tonnage of silage. In upper Wisconsin, for example, it is reported that succulent feeds for dairy cow rations in winter may often be supplied more economically and satisfactorily through the use of roots or sunflower silage than by relying exclusively upon corn for silage.

The *Mammoth Russian* is the chief variety of sunflower grown in this country. It is planted about the same time as corn. A corn planter may be used in planting. A grain drill may also be used by stopping a certain number of holes. The rows should be 30 to 36 inches apart. Seeding is at the rate of 6 to 8 pounds per acre. Sunflowers are cultivated and harvested like corn.

CHAPTER XXXI

SUGAR BEETS AND OTHER ROOT CROPS

SUGAR BEETS

Sugar beets, *Beta vulgaris*, belong to the Chenopodiaceae or goosefoot family of plants. The sugar beet is a biennial plant, storing food the first year in an enlarged tap root. The second-year stems, 3 to 4 feet in height, may be produced, bearing the flowering branches.

Sugar-Beet-Production Statistics. Sugar beets have become one of the leading sources of sugar in the United States, and furnish an even greater proportion of the sugar used in European countries. The cheapness and abundance of the supply of this energy-producing food is due largely to the development of the beet-sugar industry during the past century.

During the period 1927 to 1936, the average annual production of sugar beets in the United States was 8,383,000 tons. In the year 1938, the tonnages produced by the leading states in production were as follows: California, 2,129,000; Colorado, 2,001,000; Idaho, 1,122,000; Nebraska, 1,111,000; Michigan, 1,005,000; Montana, 987,000; Utah, 814,000; Wyoming, 684,000; Ohio, 366,000. The total production for the United States in the year 1938 was 11,614,000 tons.

Climatic and Soil Factors in Sugar-Beet Production. The 1938 Yearbook of Agriculture (178) indicates that, although many districts of northern United States have suitable conditions of temperature, other factors, such as type of agriculture, economic conditions, soil conditions, and hazards of disease, have limited the production of sugar beets chiefly to the irrigated sections of the West, the Lake States, and the Middle West.

In the humid region, the chief centers of sugar-beet production are in the Saginaw Valley of Michigan, northwestern Ohio, northern Iowa, southern Minnesota, and the Red River Valley in North Dakota and Minnesota. Under irrigated conditions, sugar beets are grown in the Scott's Bluff area of Nebraska, the northeastern part of Colorado, the Arkansas Valley of Colorado, western Kansas, the Yellowstone Valley

of Montana, southern Idaho, irrigated valleys of Utah, certain sections of California, and in northwestern South Dakota.

Sugar Beets in Crop Rotations. The sugar-beet crop is a valuable one in the rotations of regions adapted to it. The production of a good crop of beets requires thorough preparation of the soil and careful cultivation, thus controlling weeds and leaving the land in excellent condition without the need of plowing for a following crop of oats, barley, or spring wheat, or, if the beets are harvested sufficiently early, of rye or winter wheat. If the tops are returned to the soil or if manure from feeding the tops and pulp is applied to the land, less of the mineral elements of fertility is removed from the soil by beets than by any other cash crop grown in sugar-beet regions. As a cash crop, sugar beets are among the most profitable, but they require a large amount of hand labor, and ample provision must be made for the proper handling of the crop.

It is usual for beets to be grown after corn, beans, or potatoes, which leave the land comparatively free of weeds. Clover sod, plowed in the fall, can be put in excellent shape for beets by proper fitting in the spring. Alfalfa or grass sods should be followed by a season of corn, beans, or any other cultivated crop before planting to beets, because of the expense involved in keeping down voluntary alfalfa, weeds, and grass. In Michigan, Wisconsin, Ohio, and Indiana, sugar beets are grown usually in the following rotations: *A* (1) clover; (2) corn, beans, or potatoes; (3) beets; (4) oats, barley, or rye, seeded to clover. *B* (1) corn, beans, or potatoes; (2) beets; (3) oats or barley, seeded to alfalfa; (4), (5), (6) alfalfa. In Colorado and Kansas, cantaloups, cucumbers, potatoes, and canning crops, such as peas, beans, and tomatoes, may be included in rotation with beets, small grain, and alfalfa.

It is not a good practice to grow beets year after year on the same land. Not only is fertility depleted and the organic content of the soil reduced but also great loss must be expected from fungus diseases, such as the leaf spot, and from insect injury, particularly from the root nematodes. Growing beets in a proper rotation effectively controls most of the insect pests, such as cutworms, white grubs, wireworms, beet-root aphids, root nematodes, and minor pests. Rotation is the only practical way of controlling leaf spot, the fungus disease which causes the most loss in beet growing.

Fertility Requirements and Practices for Sugar Beets. Under average conditions, sugar beets respond best to substantial applications of complete fertilizer, high in phosphoric acid and potash. From

300 to 500 pounds per acre of a complete fertilizer, such as 2–12–6 or 4–12–4, give most profitable results. The bulk of the fertilizer should be applied during the preparation of the seed bed or should be broadcasted and harrowed in just before planting. A smaller application of 100 to 125 pounds per acre may be applied in the row through a special fertilizer attachment on the seeder. It is a common practice, and a poor one, to apply a fertilizer of low analysis, in quantities that are not sufficient for maximum returns per acre.

Barnyard manure is one of the most valuable fertilizers to use for beets. Ample applications, 6 or more tons per acre, applied the year previous to planting beets, give the best results. Spring applications, made immediately before planting beets, are not recommended since there is not sufficient time for proper incorporation with the soil, and short, prongy, low-yielding beets may result. The weed seeds carried in fresh manure greatly increase the cost of weeding. Only well-composted and well-rotted manure may be applied profitably in the spring. Manure should be supplemented with an application of 300 pounds of superphosphate or of a fertilizer high in phosphorus and potash.

On acid soils, sugar-beet refuse lime, used at the rate of 2 to 4 tons per acre, or 1 or 2 tons of finely ground limestone, applied in rotation when fitting seed beds for corn or beets, will directly increase beet yields and markedly increase the yields of the clover and alfalfa following in rotation, thus supplying a greater residue of organic matter and nitrogen, improving both the fertility and structure of the soil.

Refuse lime can be secured from the beet-sugar factory. This lime contains 50 to 80 per cent of calcium carbonate and small percentages (less than 1 per cent) of nitrogen, phosphoric acid, and potash. It is excellent for correcting soil acidity and has a slight, though appreciable, fertilizing value. After hauling beets to the factory, wagons should return loaded with refuse lime for later application.

Sugar-Beet Seed. As the so-called sugar-beet seed is in reality a seed ball containing a number of individual seeds, it is necessary to thin carefully by hand when plants are young. Sugar-beet seed is usually supplied at cost by the sugar-beet company with whom the grower has a contract. Special efforts are made to secure seed of good germination from strains that give a high yield and a high sugar content—an average of 13 per cent and above. It is advisable, however, for the grower to test germination before planting.

Before the first World War, practically all sugar-beet seed was imported, most of it being of the *Kleinwanzlebener* or *Vilmorin* va-

riety, produced in Germany. When the last war cut off the foreign supply, the home production of sugar-beet seed became important and many western beet-sugar companies grew a large part of their seed. In Michigan, also, the production of sugar-beet seed developed on a large scale, several companies producing as much as half or more of the seed used.

Recent developments in breeding methods by the United States Department of Agriculture have greatly expanded sugar-beet-seed production in the United States, particularly in western producing regions, where disease-resistant strains are in great demand.

Good sugar-beet seed not only must be of high germination and from high-yielding strains but also must be produced from strains of beets carefully selected for high sugar content.

In the production of sugar-beet seed, the first step is the selection of mother beets of high sugar content which will produce progeny equally high in sugar. A great number of beets are analyzed, and the best individuals are carefully stored in moist sand. The following year these are planted separately, and seed from each plant is preserved and planted the third year in numbered plots. A remnant of seed of each plot is retained. The progeny of each strain is analyzed, the poorer strains are discarded, and the good ones are used in producing mother seed which is increased in sufficient quantity for planting on a larger scale.

In planting beets for commercial seed purposes, about 8 pounds of seed are used to the acre, in rows 18 inches apart. The plants may be thinned to 3 or 4 inches apart, or left unthinned to save labor. The *stecklings,* as are called the small beets produced, are stored in moist sand, protected from freezing by layers of straw and earth, with ventilators every few feet along the top of the heaps. Early the following spring, the mother beets are planted in fall-plowed land, in rows varying from 30 to 36 inches apart, with the beets the same distance apart in the rows. A spade is pushed into the ground and thrust forward, the mother beet inserted, and the earth pressed around so that it slightly covers the crown. Weeds are kept in check by thorough cultivation and hoeing. In harvesting, the seed stalks are cut with a sickle and piled in the field to cure for threshing, which is accomplished with an ordinary grain separator. Yields of 800 to 1800 pounds per acre can be expected. At the Utah Experiment Station, an average yield of 1461 pounds of seed per acre was reported for a six-year period. It is important that the sugar-beet-seed industry be further developed and maintained in America in order that

the American beet-sugar industry may be independent of a foreign seed supply.

The yield of beets depends largely on the stand secured. A uniform stand can only be obtained by planting on a well-prepared seed bed and giving proper attention to thinning and cultivating. The seed bed is the foundation of a good stand.

Fall-plowed land can be prepared at an earlier date in the spring, and offers a longer period for working into proper condition than spring-plowed land. By discing and harrowing frequently with the spike-tooth and spring-tooth harrows and rolling with the cultipacker, such land can be best brought into proper condition for planting. Spring-plowed land should be firmed with a weighted roller or cultipacker, and harrowed immediately after plowing. It should then be disced and harrowed at frequent intervals until planting. The final preparation immediately before planting on either spring-plowed or fall-plowed land should be made with a spike-tooth harrow or a heavy plank drag. Intensified effort in preparing the best possible seed bed will repay the grower by greatly lessening the work and expense of weed control after the crop is planted.

Seeding Sugar Beets. The date of planting varies with the region; it usually coincides with corn-planting time. In Michigan, northern Ohio, northern Indiana, and Wisconsin, planting time ranges from May 1 to May 20. In the Mississippi Valley the planting season begins as early as April 1, continuing until May 1. In Southern California the planting season ranges from October 1 to April 1, and in the Sacramento and San Joachim Valleys planting dates range from January 15 to March 15. The proper period for planting is when the soil is well warmed and the danger of severe frost is past. Comparatively early planting on a well-worked seed bed gives highest yields and quality.

The seed is drilled with a special beet drill, which may be a one-, two-, or four-row machine. The rows are 20 to 24 inches apart, usually 22 inches under Mississippi Valley and eastern conditions and 20 inches in the West.

The rate of planting varies from 12 to 20 pounds per acre, depending on germination and the condition of the land. Usually 15 pounds per acre are planted. If the seed bed is moist, the seeds should be planted $\frac{1}{2}$ to $\frac{3}{4}$ inch deep. If the seed bed is dry, they must be planted at a depth of 1 to $1\frac{1}{2}$ inches in order to insure enough moisture for germination. The use of the cultipacker, after planting and before the beets are up, will often save a beet crop on ground that has a

tendency to bake or crust over. As the so-called sugar-beet seed is in reality a seed ball containing a number of individual seeds, it is necessary to thin carefully by hand when plants are young. Sugar-beet seed is usually supplied at cost by the sugar-beet company with whom the grower has a contract. Special efforts are made to secure seed of good germination from strains that give a high yield and a high sugar content—an average of 13 per cent and above. It is advisable, however, for the grower to test germination before planting.

Blocking and Thinning of Sugar Beets. The largest yield of beets of the right size for the highest sugar content results when plants are spaced 10 to 12 inches apart in the row. The solid row of young plants must be thinned to a single plant every 10 or 12 inches. When four leaves have developed on the young plant, the first cultivation, which comes very close to the row, is given. The plants are then blocked to tufts and bunches about 8 or 10 inches apart, with a sharp-bladed, 7-inch hoe. The blade is drawn at right angles to the rows beneath the surface of the ground, so as to cut off the roots beneath the crowns. The bunches are then thinned carefully by hand to one plant. It is important that the strongest bunches be left in blocking and that, in thinning the bunches, the most vigorous plants be left in place. Careful attention to blocking and thinning will be repaid by a much more uniform stand and increased yield. Labor is usually paid on an acre basis; hence there is a tendency on the part of some workmen to pull the larger plants, which are easier to handle, and to leave the smaller and weaker ones in place. The grower should give careful supervision to blocking and thinning, and it is usually advisable that a special bonus be paid to the laborers for an increase in yield secured over the average yield of the district.

Cultivation of Sugar Beets. The first cultivation should be made as soon as the plants show plainly in the row and when two to four leaves have formed. This cultivation should be very carefully performed since a good job greatly reduces the work of blocking and thinning. From a week to ten days after these operations, the second cultivation is given, and thereafter the crop is cultivated every week or ten days until the best leaves block the rows. Usually four to six cultivations are necessary. The first and second cultivations should be close to the plants and may be fairly deep between the rows, but later cultivations should be shallow, not more than 2 to 3 inches deep, in order not to prune the feeding roots of the plants which tend to interlace between the rows after thirty-five to forty days' growth. The cultivation of beets is best handled by the use of the regular two-

and four-row beet cultivator equipped with disc or knife weeders. Frequent and careful cultivation is necessary in order to secure good yields and high sugar content.

The first hoeing is given about ten days after blocking and thinning, the dirt being carefully drawn about the plants without covering the crowns. This is followed by one or two hoeings at intervals of a week or ten days, to clear the weeds from between the plants. The careful grower cultivates close to the rows early in the season, taking out as many weeds as possible with machinery. He sees to it that the hoeing is carefully done in order to get all weeds between the plants without thinning the stand by cutting out the plants. The beet crop *must be kept free of weeds.*

Harvesting Sugar Beets. Since sugar beets make rapid growth and store the most sugar as maturity approaches, they should be left in the field until the right stage of maturity is reached. Proper maturity is indicated by the browning of the lower leaves and by a wilted or drooping appearance of the plants. Tests of sugar content are made by factory experts, and notice is usually given the grower when to begin to harvest. Harvesting generally begins in September and continues through October and into November, though in parts of California beet harvest may begin in July. A special harvesting implement is used to raise the beets in the rows.

After being lifted, the beets are pulled by hand, care being taken to knock off clinging dirt by striking the beets together, a bunch in each hand. The usual practice is to throw the lifted beets into piles, the topping being done from the heap so collected. A heavy knife is used in topping, the crowns being cut off at the base of the first leaf, or slightly above the "sunline." The topped beets are thrown into heaps and covered with tops to prevent excessive loss of moisture. As soon as possible, they should be hauled to loading stations or factories to prevent drying and freezing, since repeated freezing and thawing makes sugar extraction difficult.

It is important to both grower and manufacturer that beets be carefully topped. The crown and leaves of the sugar beets are relatively high in potash and phosphoric acid. By retaining them on the land or feeding them on the farm, much of the mineral fertility contained in the beet top is returned. The salts contained in the crown prevent proper crystallization in the process of sugar manufacture; hence manufacturers are fully justified in making deductions for the amount of tare due to poor topping.

Average yields per acre range 8 to 10 tons, but good growers frequently secure 12 to 14 tons, and exceptional yields range from 15 to 18 tons.

Beer-Sugar Manufacturing. After harvest, the sugar beets are hauled from the fields to collection stations or to the sugar factory. At the factory they are stored in large heaps and in bins. The first step in the process of manufacture consists in removing all dirt by washing and then weighing the thoroughly clean beets. The beets are then passed through a slicing machine which cuts the beets into thin strips termed *cossettes*. The cossettes pass on to iron cylinders or diffusion batteries, where they are subjected to a continual flow of warm water which removes the sugar by diffusion from the thin slices. The beet juice then passes to the carbonation tanks, where it is treated with a caustic lime solution and carbon dioxide which purifies the juice, causing impurities to settle to the bottom, leaving a clear liquid. The pulp left is crushed or dried and makes a valuable stock feed. The liquid is then filtered, retreated with a small amount of the lime solution and carbon dioxide, and again filtered. The alkilinity caused by the lime is then reduced by treating with sulphur fumes, after which the juice is again filtered and is in condition for evaporation. This is accomplished by heating in a partial vacuum. When about half the water is removed from the juice, the sulphur treatment is again applied and the juice filtered. This thick juice is passed next through the vacuum pan, and moisture is removed to a point where crystallization occurs. The mixture of crystals and syrup, known as *massecuite*, is put through a centrifugal machine which throws out the syrup. Then the sugar is dried and sacked for market. A beet-sugar factory represents an outlay of capital of $1,000,000 to $3,000,000. The average operating season ranges from two to three months.

Use of Tops, Leaves, and Sugar-Beet Pulp. Beet tops and leaves furnish excellent feed for livestock. When left on the ground, they may be pastured profitably by cattle and sheep. Until animals are accustomed to the feed, they should be turned on the field for short intervals, covering a period of several days. If fed judiciously, a large part of the ration can be composed of tops and leaves without causing scouring. A more economical method of using tops and leaves is to ensile them in well-drained pits, 2 or 3 feet deep, with a foot of straw in the bottom, then a foot of tops and leaves thrown in, then straw and tops placed in alternate layers, the heap being covered with a foot or more of straw and enough dirt to keep the pile from

freezing. One-third of the ration fed to dairy stock, or one-half of the ration fed to fattening steers, may consist of beet tops and crowns with good results.

Under western conditions, the tops occasionally are cured in the field and stacked like hay, though considerable loss of leaves is experienced when handled in this manner.

A valuable, concentrated feed for dairy cows is made from dried beet pulp. Near the factories, this pulp may be fed in a wet condition.

Research with Sugar Beets and with the Beet-Sugar Industry. The following, from Senate Document 65 (130), provides information relating to research with sugar beets and the beet-sugar industry.

Agricultural Research

1. Varietal improvement in sugar beets, including studies on sucrose content and purity as affected by cultural practices and available varieties, and development of improved varieties for higher sugar content and disease resistance.

2. Development of strains of sugar beets more suitable for culture under varying climatic and soil conditions existing in different areas, including studies on the relation to growth of tillage practices, types of fertilizer used, and methods of fertilizer application.

3. Studies on the conditions and treatment of soils that affect the stand, growth, yield, and quality of sugar-beets.

4. Improvement in production of sugar-beet seed, and determination of the relative value and productivity of sugar-beet seed produced annually instead of biennially.

Fundamental Research

5. Plant physiological studies of sugar synthesis in the sugar-beet and the effect of storage.

Processing

6. Sugar-beet machinery investigations, including the design and testing of machinery for use in cultivation and harvesting of beets.

7. Improvements in sugar-factory operations.

8. Investigation of substances other than sucrose in the sugar-beet and beet wastes as to nature, removal, influence on sugar quality, and possible utilization.

9. Investigation of the production of various grades of beet sugar by means of improved manufacturing processes.

OTHER ROOT CROPS

The growing of root crops for feeding dairy cattle and livestock in general is important in the Northern States and Canada. Some

farmers feed roots instead of ensilage, but many grow a half acre or more of roots to feed along with ensilage as a "conditioner." Dairymen find the addition of root crops to the regular ration an excellent means of increasing milk flow. The tonic effect of carrots upon horses is well known.

Dairy cattle on test or on exhibit at shows are kept in excellent condition because they are fed roots. Silage cannot be transported and kept in condition as roots can.

Mangel-wurzels, or mangels, are the roots most commonly grown for this purpose. Ten or twelve pounds of seed per acre are usually planted in May on a seed bed fitted as for beets and cultivated in the same manner. The rows should be 24 to 30 inches apart. After the crop is up, it should be thinned to plants every 8 to 12 inches.

The mangels are harvested with a beet lifter or pulled by hand when mature. They should be stored in a well-made pit or root cellar.

Large table beets are also used in the same way.

Rutabagas are planted in May or early June, in rows 22 to 30 inches apart, 2 pounds of seed per acre being used. They are given clean cultivation, and are harvested in the fall for storage in root cellars and later for feeding.

TABLE 48 *

YIELDS OF ROOT CROPS AT MICHIGAN STATE COLLEGE AGRICULTURAL EXPERIMENT STATION, EAST LANSING, AND AT THE SUBSTATION AT CHATHAM

	Tons per Acre	
	East Lansing 1924 to 1936	Chatham 1931 to 1934
Sugar beet	13.91	
Giant-feeding, half-sugar mangel	21.67	
Danish sludstrap mangel	20.61	11.23
Mammoth long red mangel	20.15	10.38
Golden Tankard mangel	15.08	7.85
American purple-top rutabaga	11.05	20.61
Cowhorn turnip	17.77	
Turnip (cowhorn type)		26.84†
Oxheart carrot	16.38	

* Experiment Station Bulletin 168.
† Average for 3 years, 1932 to 1934.

Cowhorn turnips are often seeded with oats. One or two pounds per acre are used and the turnips are pastured with sheep or hogs after the oats are harvested.

Carrots are planted in rows 28 inches apart (4 pounds of seed per acre on a well-fitted seed bed) in May or June, and are given clean culture. They start slowly and hence careful fitting of the seed bed and early and thorough preparation are necessary.

Table 48 indicates to some extent the yields of various root crops. The composition of the various root crops is presented in Table 49 of the Appendix.

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APPENDIX

TABLE 49

The Percentage Composition of Feedstuffs Used in Animal Feeding

Grains, Seeds, and Mill Concentrates

Feedstuff	Moisture	Ash	Crude Protein	Ether Extract *	Crude Fiber	Nitrogen-Free Extract †	Calcium ‡	Phosphorus ‡
	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)
Barley	9.6	2.9	12.8	2.3	5.5	66.9	0.07	0.32
Barley feed	7.9	4.9	15.0	4.0	13.7	54.5	0.03	0.41
Bread, kiln dried	10.5	2.1	12.5	1.6	0.4	72.9	0.03	0.12
Brewers' dried grains:								
18 to 23 per cent protein	7.9	4.1	20.7	7.2	17.6	42.5	0.16	0.47
23 to 28 per cent protein	7.7	4.3	25.4	6.3	16.0	40.3	0.16	0.47
Brewers' rice	11.6	0.7	7.0	0.8	0.6	79.3	0.03	0.25
Buckwheat	12.6	2.0	10.0	2.2	8.7	64.5		
Buckwheat middlings	12.4	4.6	28.0	6.6	5.3	43.1		
Cocoa shells	9.2	8.2	16.4	5.4	15.8	45.0		
Coconut cake	10.7	4.0	19.1	11.0	14.1	41.1		
Coconut meal, old process	7.3	5.5	21.3	10.0	9.4	46.5	0.28	0.58
Coconut meal, new process	8.9	6.6	21.4	2.4	13.3	47.4	0.28	0.58
Corn, shelled	12.9	1.3	9.3	4.3	1.9	70.3	0.01	0.26
Corn bran	10.0	2.1	10.0	6.6	8.8	62.5	0.03	0.14
Corn chop	11.3	1.4	9.8	4.1	2.1	71.3	0.01	0.26
Corn (ear) chop	10.7	2.0	8.2	3.4	9.2	66.5		
Corn-feed meal	10.8	1.9	10.5	5.3	2.9	68.6	0.04	0.38
Corn-germ meal	7.0	3.8	20.8	9.6	7.3	51.5	0.05	0.59
Corn-gluten feed	9.5	6.0	27.6	3.0	7.5	46.4	0.11	0.78
Corn-gluten meal	8.0	2.2	43.0	2.7	3.7	40.4	0.10	0.47
Corn-oil meal	8.7	2.2	22.1	6.8	10.8	49.4	0.06	0.62
Cotton seed, whole pressed	6.5	4.3	29.6	5.8	25.1	28.7		
Cotton-seed cake	7.5	5.9	44.1	6.4	10.3	25.8		
Cotton-seed feed, 32 per cent protein	8.3	4.8	32.1	6.4	15.3	33.1	0.20	0.73
Cotton-seed hulls	8.7	2.6	3.5	1.0	46.2	38.0		
Cotton-seed meal:								
33–38 per cent protein	7.4	5.2	36.6	5.6	15.3	29.9	0.28	1.30
38–43 per cent protein	7.3	6.1	41.0	6.5	11.9	27.2	0.19	1.11
Over 43 per cent protein	7.2	5.8	43.7	6.5	11.1	25.7	0.18	1.15
Distillers' (corn) dried grain	7.0	2.4	28.3	9.4	14.6	38.3	0.04	0.29
Distillers' (rye) dried grain	6.1	2.4	17.9	6.3	15.9	51.4	0.13	0.43
Feterita	9.1	1.7	14.2	2.9	1.4	70.7		
Hemp cake	10.8	18.0	30.8	10.2	22.6	7.6		
Hempseed, European	8.8	18.8	21.5	30.4	15.9	4.6		
Hominy feed	9.5	2.9	11.2	8.3	6.3	61.8	0.03	0.44
Kafir	11.9	1.7	11.1	3.0	2.3	70.0	0.01	0.25
Kafir-head chops	10.4	3.9	10.9	2.5	6.0	66.3	0.09	0.20
Linseed meal:								
33 to 38 per cent protein	8.5	5.6	35.3	5.4	8.3	36.9	0.36	0.84
38 to 43 per cent protein	8.5	5.3	40.4	5.8	7.5	32.5	0.33	0.74
Malt	7.7	2.9	12.4	2.1	6.0	68.9		

* Fat. † Carbohydrates except fiber. ‡ Blanks indicate that data are lacking.

TABLE 49—*Continued*

Grains, Seeds, and Mill Concentrates—*Continued*

Feedstuff	Moisture	Ash	Crude Protein	Ether Extract *	Crude Fiber	Nitrogen-Free Extract †	Calcium ‡	Phosphorus ‡
	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)
Malt sprouts	7.3	6.1	28.1	1.8	13.3	43.4	0.26	0.68
Mesquite beans and pods	6.6	4.5	13.0	2.7	22.8	50.4		
Millet, foxtail	10.1	3.3	12.6	4.3	8.4	61.3		
Millet, proso or hog millet	9.8	3.4	12.0	3.4	7.9	63.5		
Milo	9.3	1.6	12.5	3.2	1.5	71.9		
Milo-head chops	10.4	4.3	10.7	2.6	7.1	64.9		
Molasses, cane	24.0	6.8	3.1			66.1	0.35	0.06
Oats, grain	7.7	3.5	12.5	4.4	11.2	60.7	0.10	0.40
Oat chops	8.9	3.9	12.8	5.0	11.8	57.6	0.10	0.36
Oat clips	9.0	9.3	11.8	4.5	22.7	42.7		
Oat groats, ground rolled	10.4	2.6	17.3	6.6	1.8	61.3	0.08	0.43
Oat hulls	5.8	6.5	4.3	1.9	30.8	50.7	0.09	0.12
Oatmeal	8.9	2.3	16.5	4.8	3.6	63.9	0.08	0.43
Oat millfeed	6.9	6.0	6.3	2.2	27.9	50.7	0.20	0.22
Palm kernel	8.4	1.8	8.4	48.8	5.8	26.8		
Palm-kernel cake	10.1	3.9	16.2	11.0	21.4	37.4		
Peanuts, kernels	5.5	2.3	30.2	47.6	2.8	11.6	0.06	0.38
Peanuts, shells on	6.0	2.8	24.7	33.1	18.0	15.4		
Peanut meal:								
38 to 43 per cent protein	6.4	4.4	41.6	7.2	16.0	24.4	0.10	0.50
43 to 48 per cent protein	6.7	4.6	45.1	7.2	14.2	22.2	0.17	0.55
over 48 per cent protein	7.0	5.0	51.4	4.8	9.2	22.6		
Rapeseed, brown Indian	5.7	6.4	21.0	41.2	12.5	13.2		
Rapeseed, common	7.3	4.2	19.5	45.0	6.0	18.0		
Rice, rough	9.7	5.4	7.3	2.0	8.6	67.0	0.10	0.10
Rice, bran	8.8	12.2	12.8	13.8	12.2	40.2	0.10	1.84
Rice hulls	6.5	21.9	2.1	0.4	44.8	24.3	0.08	0.06
Rice polish	10.0	7.6	12.4	13.2	2.8	54.0	0.03	1.52
Rice-stone bran	8.4	11.9	12.5	13.0	11.1	43.1		
Rye	9.5	1.9	11.1	1.7	2.1	73.7	0.04	0.37
Rye feed	10.2	4.0	15.6	3.2	4.3	62.7		0.59
Rye middlings	9.5	4.4	16.7	3.7	5.5	60.2		
Sesame seed	5.5	6.5	20.3	45.6	7.1	15.0		
Sesame-seed cake	9.8	10.7	37.5	14.0	6.3	21.7		
Sorgo	12.8	2.1	9.1	3.6	2.6	69.8		
Soybeans	8.0	4.8	38.9	18.0	4.8	25.5	0.22	0.67
Soybean meal:								
38 to 43 per cent protein	7.8	5.8	41.7	5.8	6.2	32.7	0.29	0.67
43 to 48 per cent protein	8.2	6.0	44.7	4.6	5.8	30.7	0.34	0.71
Sunflower seed	6.9	3.2	15.2	28.8	28.5	17.4		
Sunflower hulls	10.5	2.6	4.4	3.4	57.0	22.1		
Sunflower kernels	6.9	4.2	29.4	43.9	2.6	13.0		
Velvet beans	9.8	3.1	26.2	4.8	6.0	50.1		
Vinegar grains	6.8	2.9	19.5	7.0	17.3	46.5		
Wheat	10.6	1.8	12.0	2.0	2.0	71.6	0.05	0.38
Wheat, brown shorts	10.8	4.0	17.8	4.8	5.8	56.8		
Wheat, flour middlings	10.4	3.3	18.8	4.0	4.2	59.3	0.09	0.80
Wheat, gray shorts	11.0	4.1	17.5	4.4	5.4	57.6	0.08	0.86
Wheat, mixed feed	9.9	4.4	18.2	4.4	6.9	56.1	0.11	0.96
Wheat, red dog	11.1	2.2	18.3	3.4	2.3	62.7	0.12	0.83
Wheat, standard middlings	10.4	3.9	17.0	4.3	5.4	59.0	0.09	0.90
Wheat, white shorts	10.9	2.2	15.6	3.7	2.4	65.2		
Wheat bran	9.4	6.4	16.4	4.4	9.9	53.5	0.10	1.14
Wheat waste, shredded	8.0	1.6	12.4	1.6	2.6	73.8		
Yeast cells, dried	4.3	10.7	48.5	0.5	0.5	35.5	0.42	1.90

* Fat. † Carbohydrates except fiber. ‡ Blanks indicate that data are lacking.

TABLE 49—*Continued*

Green Forages

Feedstuff	Moisture	Ash	Crude Protein	Ether Extract *	Crude Fiber	Nitrogen-Free Extract †	Calcium ‡	Phosphorus ‡
	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)
Alfalfa, immature	79.4	2.9	5.2	0.7	3.8	8.0	0.28	0.09
Alfalfa, in bloom	77.2	1.8	3.2	0.6	7.8	9.4	0.39	0.07
Alsike clover, immature	81.2	2.4	4.9	0.6	3.1	7.8	0.26	0.09
Alsike clover, in bloom	74.8	2.0	3.9	0.9	7.4	11.0	0.21	0.06
Barley, immature	83.4	1.5	2.8	0.7	3.6	8.0	0.06	0.07
Barley, mature	77.1	1.6	2.2	0.5	6.4	12.2	0.05	0.07
Bluegrass, Kentucky, immature	70.5	2.5	5.0	1.2	7.5	13.3	0.15	0.13
Brome grass, immature	77.5	2.9	4.3	0.9	5.2	9.2	0.14	0.10
Cabbage	90.5	0.9	2.4	0.3	1.2	4.7	0.06	0.02
Canada bluegrass, immature	74.1	2.5	4.3	1.3	6.8	11.0	0.11	0.12
Corn fodder:								
dent, immature	79.0	1.2	1.7	0.5	5.6	12.0		
dent, mature	73.4	1.5	2.0	0.9	6.7	15.5		
flint, immature	79.8	1.1	2.0	0.7	4.3	12.1		
flint, mature	77.1	1.1	2.1	0.8	4.3	14.6		
Cowpeas	82.5	2.5	3.4	0.5	4.0	7.1	0.18	0.05
Crimson clover	80.9	1.7	3.1	0.7	5.2	8.4	0.28	0.04
Kafir	73.0	2.0	2.3	0.7	6.9	15.1		
Lespedeza, Korean, immature	74.1	2.4	4.6	0.8	5.8	12.3	0.34	0.11
Meadow fescue, immature	78.8	2.6	4.0	0.9	4.7	9.0	0.15	0.11
Meadow foxtail, immature	73.9	2.8	4.5	1.2	5.6	12.0	0.15	0.12
Millet, foxtail	71.1	1.7	3.1	0.7	9.2	14.2	0.09	0.05
Oatgrass, tall, immature	78.4	3.0	4.3	1.0	4.6	8.7	0.11	0.13
Oats, immature	82.6	1.7	2.9	0.7	3.3	8.8	0.07	0.07
Oats, mature	72.0	2.1	2.7	0.9	7.4	14.9	0.08	0.08
Orchard grass, immature	78.3	2.8	3.4	1.0	5.3	9.2	0.14	0.13
Orchard grass, in bloom	73.0	2.0	2.6	0.9	8.2	13.3		
Prickly pear	78.9	4.3	0.7	0.4	2.6	13.1		
Rape	85.7	2.0	2.4	0.6	2.2	7.1		
Red clover, immature	81.2	2.7	5.0	0.8	3.0	7.3	0.27	0.10
Red clover, in bloom	70.8	2.1	4.4	1.1	8.1	13.5	0.44	0.07
Red fescue, immature	70.5	2.8	4.1	0.9	8.2	13.5	0.16	0.13
Redtop, immature	76.8	2.8	4.1	0.9	5.4	10.0	0.15	0.10
Reed canary grass, immature	80.7	2.4	3.5	0.7	4.3	8.4	0.13	0.10
Rye, immature	80.8	2.3	4.5	1.1	3.4	7.9	0.10	0.10
Rye, mature	76.6	1.8	2.6	0.6	11.6	6.8	0.08	0.06
Ryegrass, Italian, immature	77.3	2.5	3.5	1.0	5.2	10.5	0.13	0.12
Ryegrass, perennial, immature	75.9	3.0	3.8	0.9	5.4	11.0	0.15	0.12
Sorgo	77.3	1.3	1.5	1.0	6.2	12.7		
Soybeans	73.9	2.9	4.0	1.1	7.6	10.5	0.28	0.05
Sweet clover, immature	75.3	2.2	5.3	0.7	6.7	9.8	0.26	0.07
Sweet corn	79.1	1.3	1.9	0.5	4.4	12.8		
Timothy, immature	74.9	2.3	4.1	0.9	5.4	12.4	0.12	0.11
Timothy, in bloom	61.6	2.1	3.1	1.2	11.8	20.2	0.13	0.05
Wheat, immature	82.3	2.1	3.8	0.9	3.0	7.9	0.07	0.10
Wheat, mature	68.7	2.6	2.4	0.7	8.6	17.0	0.06	0.08
White clover, immature	82.0	2.1	4.9	0.6	3.1	7.3	0.23	0.09
White clover, wild, immature	81.2	2.2	5.2	0.6	2.9	7.9	0.25	0.10

* Fat. † Carbohydrates except fiber. ‡ Blanks indicate that data are lacking.

TABLE 49—*Continued*

Dried Forages

Feedstuff	Moisture	Ash	Crude Protein	Ether Extract *	Crude Fiber	Nitrogen-Free Extract †	Calcium ‡	Phosphorus ‡
	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)
Alfalfa hay	7.2	8.0	15.4	1.6	30.3	37.5	1.51	0.21
Alfalfa meal	8.2	10.0	15.2	2.2	27.5	36.9	1.56	0.22
Alfalfa meal, dehydrated	6.6	10.0	16.9	2.6	25.4	38.5		
Alfalfa-leaf meal	8.5	14.4	20.9	2.6	15.7	37.9	1.42	0.25
Alfalfa-stem meal	9.1	7.7	11.4	1.3	36.1	34.4		
Alsike clover hay	10.5	8.8	14.4	2.5	24.7	39.1	0.78	0.20
Australian saltbush hay	6.7	16.9	16.1	1.8	21.5	37.0		
Barley hay	15.0	6.4	6.7	1.6	21.4	48.9	0.17	0.25
Barley straw	14.2	5.7	3.5	1.5	36.0	39.1		
Bermuda grass hay	8.9	7.9	7.2	1.7	24.9	49.4	0.60	0.16
Black grama hay	5.5	7.0	4.3	1.3	31.4	50.5	0.22	0.09
Blue grama hay	10.9	8.5	6.7	1.8	27.9	44.2		
Bluegrass hay, immature	7.3	7.9	15.2	3.0	23.7	42.9	0.45	0.35
Bluegrass hay, bloom	11.9	7.0	9.3	3.4	27.9	40.5	0.30	0.21
Bluejoint grass hay	7.5	6.9	6.7	3.0	34.2	41.7		
Brome grass hay	14.0	9.7	9.3	1.8	26.6	38.6		
Buckwheat straw	9.9	5.5	5.2	1.3	43.0	35.1		
Buffalo grass hay	6.2	10.8	5.6	1.7	26.1	49.6		
Bur clover hay	8.7	12.3	15.7	3.0	25.5	34.8	1.11	0.15
Corncobs	10.7	1.4	2.4	0.5	30.1	54.9		
Corn fodder	11.8	5.8	7.4	2.4	23.0	49.6		
Corn husks	9.8	2.9	2.9	0.7	30.7	53.0		
Corn leaves	11.8	8.5	8.1	2.2	24.4	45.0		
Corn stalks	11.7	4.6	4.8	1.8	32.7	44.4		
Corn stover	10.7	6.1	5.7	1.5	30.3	45.7	0.45	0.10
Cowpea hay	9.7	12.9	17.5	2.8	20.5	36.6	1.84	0.25
Cowpea straw	9.7	5.3	7.4	1.3	41.5	34.8		
Crabgrass hay	9.0	7.9	6.5	2.2	32.1	42.3	0.33	0.17
Crimson clover hay	9.6	8.6	15.2	2.8	27.2	36.6	1.18	0.13
Feterita fodder	13.3	6.4	8.7	1.9	21.5	48.2	0.27	0.19
Field pea hay	10.6	8.3	16.1	2.7	24.8	37.5		
Flax straw	6.2	3.8	7.8	2.1	46.9	33.2		
Hegari fodder	13.5	8.2	6.2	1.7	16.7	53.7	0.17	0.18
Hegari stover	15.1	9.7	4.5	1.9	26.6	42.2	0.38	0.09
Johnson grass hay	7.2	7.2	8.1	2.8	30.4	44.3	0.55	0.40
Kafir fodder	9.1	7.8	6.6	2.1	28.4	46.0	0.31	0.05
Kafir stover	12.6	9.0	5.8	1.7	27.5	43.4		
Lespedeza hay	7.9	6.2	11.9	2.8	28.5	42.7	0.80	0.25
Little bluestem hay	8.6	4.9	4.0	1.6	35.4	45.5		
Meadow fescue hay	11.6	7.0	6.6	2.0	31.6	41.2		
Millet hay, foxtail	7.0	8.2	9.2	2.8	28.0	44.8		
Millet hay, pearl or cattail	10.1	9.7	9.0	1.8	32.3	37.1		
Natal grass hay	7.5	4.8	3.7	1.4	39.5	43.1	0.49	0.32
Oat grass, tall, hay	8.1	6.4	9.4	2.7	29.8	43.6		
Oat hay	11.8	5.7	6.1	2.4	27.1	46.9	0.27	0.22
Oat straw	8.1	7.6	4.4	2.5	36.2	41.2	0.23	0.20
Orchard grass hay, immature	9.9	6.0	8.1	2.6	32.4	41.0	0.31	0.18
Orchard grass hay, mature	9.9	7.0	6.9	3.0	32.7	40.5		
Prairie hay (Colorado, Wyoming)	5.5	7.2	7.0	2.4	31.3	46.6		
Prairie hay (Kansas, Oklahoma)	9.5	7.5	4.4	2.3	30.4	45.9	0.55	0.07
Prairie hay (Minnesota, South Dakota)	11.6	7.2	6.0	2.4	30.3	42.5	0.44	0.11
Red clover hay	7.0	10.0	16.1	2.6	23.6	40.7	1.01	0.14
Red clover, mammoth, hay	12.2	7.5	12.8	3.3	27.1	37.1		
Redtop hay	8.9	5.2	7.9	1.9	28.6	47.5	0.35	0.18
Rhodes grass hay	8.6	8.4	5.3	1.2	33.4	43.1		

* Fat. † Carbohydrates except fiber. ‡ Blanks indicate that data are lacking.

TABLE 49—*Continued*

Dried Forages—*Continued*

Feedstuff	Moisture	Ash	Crude Protein	Ether Extract *	Crude Fiber	Nitrogen-Free Extract †	Calcium ‡	Phosphorus ‡
	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)
Rice straw	8.9	13.5	4.5	1.6	34.0	37.5	0.18	0.05
Rye hay	6.4	4.7	5.9	2.0	37.4	43.6	0.27	0.22
Rye straw	7.1	3.2	3.0	1.2	38.9	46.6		
Ryegrass, perennial, hay	10.2	8.6	8.6	4.1	24.5	44.0	0.17	0.11
Ryegrass, Italian, hay	8.5	6.9	7.5	1.7	30.5	44.9		
Ryegrass hay	8.3	8.5	6.3	2.0	33.0	41.9		
Sedge, western species	5.4	6.7	11.6	2.4	27.4	46.5		
Slender wheat grass	7.5	6.6	7.8	2.1	30.8	45.2		
Sorgo fodder	11.6	6.0	5.3	2.4	26.0	48.7	0.27	0.15
Sorgo hay	5.8	9.5	9.5	1.9	26.8	46.5	0.31	0.09
Soybean hay	8.4	8.9	15.8	3.8	24.3	38.8	1.26	0.22
Soybean straw	8.7	7.4	5.7	2.5	34.6	41.1		
Sudan grass hay	5.3	8.1	9.7	1.7	27.9	47.3	0.47	0.24
Sweet clover hay	8.1	7.5	16.2	2.8	25.9	39.5	0.74	0.08
Sweet clover straw	5.1	3.4	6.7	1.2	49.6	34.0		
Timothy hay	7.1	5.8	7.5	2.9	30.2	46.5	0.31	0.13
Vetch, hairy, hay	13.1	8.4	20.9	2.7	24.2	30.7	0.25	0.30
Western needle grass hay	9.9	6.2	5.5	2.7	33.2	42.5		
Western wheat grass hay	8.6	8.7	8.4	2.3	31.9	40.1		
Wheat hay	9.6	4.2	3.4	1.3	38.1	43.4	0.14	0.15
Wheat straw	6.8	5.4	4.3	3.4	36.8	43.3		
White clover hay	7.2	9.4	15.6	2.2	22.7	42.9	1.31	0.28
Wire grass hay	8.5	7.3	6.6	1.3	34.6	41.7		

Silages, Roots, Tubers, and By-Products

Feedstuff	Moisture	Ash	Crude Protein	Ether Extract *	Crude Fiber	Nitrogen-Free Extract †	Calcium ‡	Phosphorus ‡
Alfalfa silage	68.9	2.7	5.7	1.0	8.8	12.9		
Alfalfa-molasses silage	68.6	3.4	5.8	1.0	8.4	12.8		
Apple pomace	78.6	0.6	1.3	1.2	3.7	14.6	0.02	0.01
Apple silage	87.6	0.6	0.7	0.7	1.8	8.6		
Beet pulp, dried	9.2	3.2	9.3	0.8	20.0	57.5	0.66	0.06
Beet pulp, molasses, dried	8.0	5.2	11.6	0.7	16.4	58.1	0.59	0.09
Carrots	88.6	1.0	1.1	0.4	1.3	7.6		
Cassava	63.8	1.4	1.0	0.3	0.8	32.7		
Corn silage	73.8	1.7	2.1	0.8	6.3	15.3	0.08	0.08
Corn silage, immature	79.1	1.4	1.7	0.8	6.0	11.0		
Corn silage, mature	70.9	1.4	2.4	0.9	6.9	17.5		
Corn stover silage	80.7	1.8	1.8	0.6	5.6	9.5		
Cowpea silage	77.8	2.1	3.2	0.9	6.5	9.5		
Hegari silage	66.3	3.4	2.3	0.8	6.7	20.5		
Jerusalem artichokes	78.7	1.1	2.5	0.2	0.8	16.7		
Mangel-wurzel	90.8	1.0	1.4	0.2	0.9	5.7	0.02	0.02
Napier grass silage	67.5	1.8	1.2	0.7	14.4	14.4	0.10	0.10
Parsnips	80.0	1.3	2.2	0.4	1.3	14.8		
Pea-vine silage	75.1	1.7	3.0	0.9	8.1	11.2		
Potatoes	78.9	1.0	2.1	0.1	0.6	17.3	0.01	0.06
Red clover silage	72.0	2.6	4.2	1.2	8.4	11.6		
Rutabagas	88.6	1.2	1.2	0.2	1.3	7.5	0.05	0.04
Sorgo silage	74.7	1.4	1.6	1.0	6.9	14.4	0.09	0.04
Soybean silage	75.6	2.6	2.4	0.8	9.6	9.0	0.29	0.10
Sugar beets	78.0	1.0	1.5	0.1	2.9	16.5	0.05	0.06
Sugar-beet pulp	90.5	0.4	0.9	0.2	2.2	5.8		
Sunflower silage	77.9	2.1	1.8	1.6	6.5	10.1		
Sweet clover silage	70.2	2.9	6.1	1.0	9.7	10.1		
Sweet potatoes	71.1	1.0	1.5	0.4	1.3	24.7	0.02	0.05
Turnips	90.6	0.8	1.3	0.2	1.2	5.9	0.05	0.05

* Fat. † Carbohydrates except fiber. ‡ Blanks indicate that data are lacking.

TABLE 50

The Digestible Protein and Total Digestible Nutrient Content of Feedstuffs As Determined for Cattle, Sheep, and Swine

Grains, Seeds, and Mill Concentrates

Feedstuff	Digestible Protein			Total Digestible Nutrients		
	Cattle	Sheep	Swine	Cattle	Sheep	Swine
	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)
Barley		10.0	9.6		77.1	74.3
Barley feed		13.2	14.3		81.2	83.3
Brewers' dried grains:						
18 to 23 per cent protein	15.5	16.3	15.1	68.3	65.0	48.5
23 to 28 per cent protein		20.8			71.9	
Buckwheat		7.2	7.2		62.2	68.5
Buckwheat middlings	25.5	23.8		77.3	73.7	
Cocoa shells		2.0			55.5	
Coconut cake			14.1			84.9
Coconut meal, old process		17.5			83.8	
Corn, shelled	5.2	7.5	7.2	78.3	73.9	80.0
Corn bran	5.2	5.3		59.9	72.9	
Corn chop			7.7			82.0
Corn, ear, chop	4.8	5.7	6.2	68.6	75.6	70.2
Corn-feed meal			7.9			80.6
Corn-gluten feed		23.2			77.9	
Corn-gluten meal		37.8			78.4	
Corn-oil meal		17.0			80.8	
Cotton seed, whole pressed	15.1	21.6		57.1	64.2	
Cotton seed feed		27.3			79.7	
Cotton seed hulls	0.5			35.7	24.8	
Cotton-seed meal:						
33 to 38 per cent protein	31.5	28.2	31.1	63.6	65.7	67.1
38 to 43 per cent protein	35.3	31.6	34.9	66.7	68.0	69.8
over 43 per cent protein	37.6	33.6	37.1	67.9	68.7	70.8
Distillers' (corn) dried grain		20.1			81.6	
Feterita		10.9			81.0	
Hominy feed		8.2			88.3	
Kafir	9.0	7.1	8.5	79.7	70.9	81.4
Kafir head chops		6.9			67.8	
Linseed meal:						
33 to 38 per cent protein		29.7	31.4		76.0	71.6
38 to 43 per cent protein		33.9	36.0		77.0	73.1
Malt sprouts		21.7			71.2	
Mesquite beans, pods on		11.7			71.9	
Millet, proso or hog millet		7.3	8.2		69.2	73.7
Milo	8.3	9.5	7.6	75.9	85.6	72.7
Milo head chops		8.1			76.0	
Molasses	0.2	0.8		57.0	62.3	
Oats, grain	9.1	9.4	9.9	72.3	76.0	74.3
Oat clips		4.7			52.0	
Oat groats, ground rolled		15.6			91.4	
Oat hulls	2.2	0.7	2.5	58.7	42.5	25.0
Oat millfeed		4.2			48.2	
Palm-kernel cake			11.3			67.1
Peanuts (shells on)		20.0			97.4	
Peanut meal:						
38 to 43 per cent protein		37.0			78.8	
43 to 48 per cent protein		40.1			79.4	
over 48 per cent protein		45.7			78.3	
Rice, rough		5.5			70.7	
Rice, bran	8.3	8.8	8.6	58.4	67.5	65.9
Rice hulls		0.1			8.0	
Rice polish	8.2	8.8	10.3	81.0	85.6	89.1
Rye		9.3			79.6 *	

* Crude fiber not included in calculation.

TABLE 50—*Continued*

Grains, Seeds, and Mill Concentrates—*Continued*

Feedstuff	Digestible Protein			Total Digestible Nutrients		
	Cattle	Sheep	Swine	Cattle	Sheep	Swine
	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)
Rye feed		11.5	13.4		68.3	77.7
Sesame seed cake		34.5			84.1	
Sorgo	4.5	4.7	5.5	71.8	64.6	69.3 *
Soybeans	35.0	35.0	36.6	92.3	90.0	97.8
Soybean meal:						
38 to 43 per cent protein		37.5			77.4	
43 to 48 per cent protein		40.2			76.2	
Sunflower seed		10.6			77.4	
Velvet beans		19.4			74.0	
Vinegar grains		12.5			62.3	
Wheat		9.1	9.1		75.9	73.0
Wheat, brown shorts		14.6			64.8	
Wheat, flour middlings	13.7	16.2	15.6	72.4	78.8	71.7 *
Wheat, mixed feed	14.3	13.9	13.5		57.4	64.9 *
Wheat, red dog			16.5			76.3 *
Wheat, standard middlings		12.9	13.9		66.8	58.8
Wheat, white shorts		14.3	11.5		87.0	69.1 †
Wheat bran	12.6	12.5	12.5	63.3	61.1	57.9
Wheat waste, shredded	8.2	9.1	9.4	70.7	65.1	69.9

Green Forages

Feedstuff	DP Cattle	DP Sheep	DP Swine	TDN Cattle	TDN Sheep	TDN Swine
Alfalfa, immature	3.8			11.8		
Barley, immature		2.0			10.8	
Brome grass, immature		2.9			9.6	
Cabbage		2.1			7.2	
Corn fodder, dent	1.1	1.1		11.2	14.4	
Cowpeas		2.6			11.0	
Crimson clover		2.4			9.8	
Millet, foxtail		2.1			19.5	
Prickly pear	0.3	0.4		12.4	11.4	
Rape		2.1			11.2	
Red clover, in bloom	2.9		1.9	19.3		13.0
Rye	2.1			17.0		
Soybeans	3.2			16.0		
Sweet clover, immature		4.1			15.7	
Sweet corn		1.2			15.1	
Timothy, immature	2.0			14.3		
White clover, immature		3.6			11.2	

Dried Forages

Feedstuff	DP Cattle	DP Sheep	DP Swine	TDN Cattle	TDN Sheep	TDN Swine
Alfalfa hay		11.7	7.9		54.4	38.6
Alfalfa meal	11.2	9.7		49.6	50.1	
Alsike clover hay	9.5			53.4		
Australian saltbush hay		13.7			44.2	
Barley hay		4.4			50.0	
Bermuda grass hay		3.7			44.3	
Bluegrass hay		5.6			50.2	
Bluejoint grass hay		4.2			47.0	
Brome grass hay		5.1			47.7	
Buffalo grass hay	3.0	3.0		53.2	48.3	
Bur-clover hay		10.8			49.2	
Corncobs		0.1			45.5	
Corn fodder	3.4			54.4		
Corn husks	0.8	0.4		65.6	54.5	
Corn stover	2.5	2.1		53.4	49.8	
Cowpea hay		12.1			47.9	

* Crude fiber not included in calculation. † No fat.

TABLE 50—*Continued*

Dried Forages—*Continued*

Feedstuff	Digestible Protein			Total Digestible Nutrients		
	Cattle	Sheep	Swine	Cattle	Sheep	Swine
	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)	(Per cent)
Crabgrass hay		2.0			46.6	
Crimson clover hay	10.3	10.5		51.4	49.2	
Field-pea hay		12.9			57.5	
Flax straw		6.3			37.5	
Johnson grass hay		3.6			53.2	
Kafir fodder	2.5	3.4		52.8	54.3	
Kafir stover	2.3	2.4		50.2	45.9	
Meadow fescue hay		3.1			50.3	
Millet hay, pearl or cattail		5.8			55.1	
Natal grass hay	0.4			47.8		
Oatgrass, tall, hay		4.4			49.1	
Oat hay		3.3			48.1	
Oat straw	1.5	0.5		45.5	39.4	
Orchard grass hay	4.9	4.3		52.4	50.1	
Prairie hay (Kansas, Oklahoma)	0.8			50.3		
Prairie hay (Minnesota, South Dakota)		2.2			44.1	
Red clover hay	9.7	9.5		49.6	50.0	
Redtop hay		4.8			53.9	
Rhodes grass hay	2.7	2.4		49.7	53.1	
Rice straw		1.0			39.1	
Ryegrass hay, Italian		2.7			56.0	
Sorgo fodder	3.3	1.7		60.2	49.4	
Soybean hay	11.2	11.4		55.6	51.3	
Soybean straw		0.9			35.0	
Sudan grass hay	3.4	5.0		53.5	49.0	
Sweet clover hay		12.3			51.5	
Timothy hay	3.5	3.3		52.5	53.5	
Vetch, hairy, hay	13.8	15.0		53.9	52.6	
Western wheatgrass hay		4.4			52.6	
Wire grass hay		3.2			51.0	

Silages, Roots, Tubers, and By-Products

Feedstuff	DP Cattle	DP Sheep	DP Swine	TDN Cattle	TDN Sheep	TDN Swine
Alfalfa silage	4.0	3.1		18.8	13.8	
Alfalfa-molasses silage	4.0			18.8		
Apple pomace	0.3			14.3	15.3	
Beet pulp, dried		5.3	3.0		73.9	70.8
Beet pulp, molasses, dried	7.7			69.3		
Carrots	0.8	0.8		10.4	9.4	
Cassava	0.2			19.6		
Corn silage	1.0	1.1		17.5	17.4	
Corn-stover silage	0.7	0.9		10.4	10.1	
Cowpea silage	1.9			13.5		
Mangel-wurzel	0.7	0.8		6.6	6.9	
Napier grass silage	0.3			14.3		
Pea-vine silage		1.6			14.3	
Potatoes	0.7	0.9	0.9	17.0	16.6	17.3
Red clover silage	1.3	1.7		10.4	14.3	
Rutabagas		1.0			9.5	
Sorgo silage		0.4			16.1	
Soybean silage	1.6			13.2		
Sugar beets		1.4			20.9	
Sunflower silage	1.0	0.8		12.6	14.1	
Sweet clover silage	4.6	4.7		17.6	16.2	
Turnips	0.8	1.1		7.8	7.9	

TABLE 51

Varietal Recommendations by States

Crop Varieties Certified by Members of the International Crop Improvement Association *

ARIZONA CROP IMPROVEMENT ASSOCIATION

R. L. Mallock, Secretary, Tucson, Arizona

CORN
- Mexican June

ALFALFA
- Chilean
- Hairy Peruvian

BARLEY
- Vaughn

WHEAT
- (a) Spring
  - Baart
  - White Federation
  - Hope

OATS
- Colorado 37

SORGHUM
- (a) Grain
  - Double Dwarf Milo
  - Hegari
- (b) Sorgos (Sweet)
  - Atlas

COLORADO SEED GROWERS' ASSOCIATION

R. P. Yates, Secretary, Fort Collins, Colorado

WHEAT
- (a) Winter
  - Kanred
  - Turkey
- (b) Spring
  - Komar
  - Ceres
  - Marquis

SORGHUM
- (a) Grain
  - Wheatland
- (b) Sorgos (Sweet)
  - Atlas
  - Coes
  - Early Sumac
- (c) Proso—Red Turghai

PEAS
- French Gray
- Agnes
- Warshauer

ALFALFA
- Grimm
- Meeker Baltic
- Hardistan
- Ladak

OATS
- Colorado 37
- Brunker
- Kanota
- Victory
- Markton

RED CLOVER

CORN
- Colorado 13
- Minnesota 13
- Reid Yellow Dent
- Crawford Yellow Dent
- Phillips Co. Yellow Dent
- Iowa Silvermine
- Logan County White

RYE
- Rosen

BARLEY
- Trebi
- Colsess
- Club Mariout
- Flynn
- Wisconsin 38

GEORGIA CROP IMPROVEMENT ASSOCIATION

R. R. Childs, Secretary, Athens, Georgia

CORN
- (a) Field
  - Whatley's Prolific
  - Improved Whatley
  - Short Golden
  - Hastings Prolific
- (b) Popcorn
  - Queen

WHEAT
- (a) Spring
  - Redhard
  - Purplestraw or Bluestem

OATS
- Bancroft

SOYBEANS
- Laredo
- Ottotan

RYE
- French

COTTON
- College 1
- Stoneville 2

IDAHO SEED GROWERS' ASSOCIATION

H. L. Spence, Secretary, Boise, Idaho

WHEAT
- (a) Winter
  - Turkey Red
- (b) Spring
  - Federation

OATS
- Idamine
- Victory
- Swedish Select

ALFALFA
- Grimm
- Cossack
- Hardigan
- Ladak

* Prepared with the assistance of O. S. Fisher, Extension Service, U.S.D.A.

TABLE 51—*Continued*

IDAHO SEED GROWERS' ASSOCIATION—*Continued*

WHEAT
Relief
Dicklow
Early Baart

VEGETABLES
Onion
Lettuce

BARLEY
Trebi

RED CLOVER
Midland
Cumberland

WHITE CLOVER
Ladino

BEANS
Great Northern

ILLINOIS CROP IMPROVEMENT ASSOCIATION

Bernice Michaels, Assistant Secretary, Urbana, Illinois

WHEAT
(*a*) Winter
Cheyenne
Fulhio
Ilred
Wis. Ped. No. 2
Illinois Prog. No. 2
(*b*) Spring
Progress

BARLEY
Wisconsin 37
Wisconsin 38

FLAX
Bison

CORN
Hybrids (Adapted to Illinois)
Canterbury Yellow Dent
Golden Glow
Gunn Western Plowman
McKeighan Yellow Dent
Reid Yellow Dent
Sommer Yellow Dent
Will County Favorite

LESPEDEZA
Korean 19604
Korean

OATS
Columbia
Gopher
Iowar
Iogold
Keystone
Kanota
Lenroe
Wisconsin State Pride

SOYBEANS
Dunfield
Illini
Manchu
Mandarin
Mandell
Mansoy
Wilson

INDIANA CORN GROWERS' ASSOCIATION

K. E. Beeson Secretary, LaFayette, Indiana

WHEAT
(*a*) Winter
Michigan Amber
Fultz
Trumbull
Fulhio
Rudy
Purdue 1
Purdue 4

OATS
Minota
Gopher
Wayne
Cartier
Columbia

SOYBEANS
Dunfield
Manchu
Illini
Laredo
Kingwa
Mandell

CORN
Hybrids
Reid Yellow Dent
Woodburn Yellow Dent
Johnson County White Clarage
Alexander Gold Standard
M. A. C.
Troyer Yellow Dent
Krug

IOWA AGRICULTURAL EXPERIMENT ASSOCIATION

J. L. Robinson, Secretary, Ames, Iowa

WHEAT
(*a*) Winter
Iobred
Iowin
Turkey Red
Kawvale
(*b*) Spring

OATS
Iowa 105
Iogold

CORN
Iowa Hybrid 942
Iowa Hybrid 931
Hi-bred 311

FLAX
Redwing

BARLEY
Spartan

TABLE 51—*Continued*

IOWA AGRICULTURAL EXPERIMENT ASSOCIATION—*Continued*

WHEAT
- Komar
- Thatcher

RYE
- Dakold

CORN
- Hi-bred 323
- Iowa Hybrid 13
- Iowa Hybrid 939
- Hi-bred 311A
- Turner E-4
- Waxy Hybrid 961

BARLEY
- Wisconsin 38

SOYBEANS
- Mukden

KANSAS CROP IMPROVEMENT ASSOCIATION

A. L. Clapp, Secretary, Manhattan, Kansas

WHEAT
- (*a*) Winter
  - Turkey
  - Kanred
  - Tenmarq
  - Blackhull
  - Fulcaster
  - Harvest Queen
  - Kawvale
  - Clarkan
  - Comanche

OATS
- Kanota
- Red Texas

BARLEY (Spring)
- Common six-row
- Flynn

FLAX
- Linota

GRASS
- Brome

CORN
- (*a*) Field
  - Reid Yellow Dent
  - Midland Yellow Dent
  - Kansas Sunflower
  - Pride of Saline
  - Freed White Dent
  - Cassel White Dent
  - Colby (Yellow Cap)
- (*b*) Popcorn
  - Supergold

SOYBEANS
- A. K.
- Manchu
- Laredo
- Peking (Sable)
- Virginia

LESPEDEZA
- Korean

SWEET CLOVER
- White-flowered Biennial

SORGHUM
- (*a*) Grain
  - Blackhull Kafir
  - Western Blackhull Kafir
  - Dawn Kafir
  - Pink Kafir
  - Red Kafir
  - Dwarf Yellow Milo
  - Wheatland
  - Feterita
  - Greeley
- (*b*) Sorgos (Sweet)
  - Atlas
  - Kansas Oranges
  - Early Sumac
  - Leoti Red
  - Sunrise
- (*c*) Sudan grass

ALFALFA
- Kansas Common
- Grimm

KENTUCKY SEED IMPROVEMENT ASSOCIATION

Ralph Kenney, Secretary, Lexington, Kentucky

WHEAT
- (*a*) Winter
  - Ashland
  - Posey Bluestem
  - Fultz
  - Currell's Prolific
  - Fulcaster
  - Trumbull

RED CLOVER
- Kentucky 101
- Kentucky 109
- Kentucky 110
- Kentucky 174
- Kentucky 175
- Kentucky 213
- Kentucky 215

OATS
- Kanota
- Fulghum
- Burt

BARLEY
- Kentucky Winter
- Tennessee Beardless

GRASS
- Orchard

LESPEDEZA
- Common
- Tennessee 76
- Korean
- Kobe
- Lespedeza sericea

CORN
- Hybrids
- Boone County White
- Reid Yellow Dent
- Pride of Saline
- Johnson County White
- Woodburn Yellow Dent
- Jarvis Golden Prolific

SORGHUM
- (*a*) Sorgos (Sweet)
  - Orange
  - Sumac
  - Amber

TOBACCO
- White Burley 5
- White Burley 16

TABLE 51—*Continued*

MICHIGAN CROP IMPROVEMENT ASSOCIATION

A. A. Johnson, Secretary, East Lansing, Michigan

WHEAT
- (a) Winter
  - American Banner
  - Red Rock
  - Baldrock

OATS
- Wolverine
- Worthy
- Iogold
- Iowa 444

FLAX
- Bison

CORN
- Duncan
- M. A. C.
- Golden Glow
- Pickett
- Polar Dent

RYE
- Rosen

BARLEY
- Spartan
- Wisconsin Pedigree 38

POTATOES
- (a) Irish
  - Irish Cobbler
  - Bliss Triumph
  - Early Ohio
  - Russet Rural
  - White Rural
  - Russet Burbank
  - Green Mountain
  - Katahdin

BEANS
- Robust
- Michelite

MINNESOTA CROP IMPROVEMENT ASSOCIATION

Ralph F. Crim, Secretary, St. Paul, Minnesota

WHEAT
- (a) Winter
  - Minturki 1507
- (b) Spring
  - Ceres
  - Thatcher 2303
- (c) Durum
  - Mindum 470

OATS
- Gopher 674
- Iogold
- Anthony 686
- Minrus 693
- Rusota
- S. D. 165

BARLEY
- Velvet 445
- Wisonsin 38
- Manchuria 184
- Peatland 452
- Glabron 447

RYE
- Dakold
- Rosen

FLAX
- Redwing 188
- Bison
- Buda

SOYBEANS
- Minsoy 139
- Wisconsin Black
- Chestnut 110
- Habaro 109
- Manchu

FIELD PEAS
- Chancellor
- Chang

ALFALFA
- Grimm
- Ladak
- A–136

CORN
- (a) Field (Open-Pollinated)
  - Early Murdock
  - Golden Jewel
  - Silver King
  - Golden King
  - Minnesota 13

CORN—*Continued*
  - Rustler
  - Minnesota 23
  - Northwestern Dent
  - Pearl Flint
  - Dakota White Flint
  - Gehu Flint
  - Field (Hybrids)
  - Minhybrid 301
  - Minhybrid 401
  - Minhybrid 402
  - Early 800
- (b) Sweet Corn
  - Golden Bantam
    - Single Crosses
      - Minhybrid 201
      - Minhybrid 202
      - Minhybrid 203
  - Golden Bantam
  - Crosby
  - Country Gentleman
  - Stowells Evergreen
- (c) Popcorn
  - Minhybrid 250
  - Japanese Hull-less

MISSOURI CORN GROWERS' ASSOCIATION

C. A. Helm, Secretary, Columbia, Missouri

CORN
- Boone County White
- Johnson County White
- Reid Yellow Dent
- Cartner
- Midland Yellow Dent
- Commercial

WHEAT
- (a) Winter
  - Michigan Wonder
  - Fulcaster
  - Poole
  - Harvest Queen
  - Fulhio

SOYBEANS
- Virginia
- Wilson
- Morse
- Manchu
- Midwest
- Laredo

TABLE 51—*Continued*

MISSOURI CORN GROWERS' ASSOCIATION—*Continued*

CORN
St. Charles White
90 Day Yellow
110 Day Yellow

WHEAT
Missouri Early Premium

OATS
Fulghum
Columbia

BARLEY (winter)
Missouri Early Beardless
Kentucky 1
Tennessee 5

MONTANA SEED GROWERS' ASSOCIATION

R. D. Mercer, Secretary, Bozeman, Montana

WHEAT
(*a*) Winter
Montana 36
Karmont
Yogo
(*b*) Spring
Marquis
Supreme
Federation

BARLEY
Horn (2-Rowed)
Trebi (6-Rowed)

SEED CORN

OATS
Victory
Markton
Idamine

RYE
Dakold
Rosen
Prolific (Spring)

FLAX
Reserve
Newland
Bison

ALFALFA
Grimm
Cossack
Ladak
A–136

RED CLOVER
Atlaswede
Cumberland

GRASS
Crested Wheat
Brome

BEANS
Great Northern

NEBRASKA CROP GROWERS' ASSOCIATION

E. L. Frolick, Secretary, Lincoln, Nebraska

WHEAT
(*a*) Winter
Cheyenne
Nebraska 60
(*b*) Spring
Ceres
Marquis
Komar
Thatcher

BARLEY
Glabron
Comfort
Spartan
Trebi
Velvet

OATS
Iogold
Nebraska 21
Kanota
Burt 293

SORGHUM
(*a*) Grain
Western Blackhull Kafir
Pink Kafir
Kalo
Early Kalo
(*b*) Sorgos (Sweet)
Atlas
Black Amber
(*c*) Sudan Grass

CORN
Nebraska Hybrid 252
Nebraska Hybrid 238
Nebraska Hybrid 362
Nebraska Hybrid 110
Iowa Hybrid 939

ALFALFA
Grimm
Cossack
Ladak
Hardistan
A–136

RYE
Rosen

NEW JERSEY FIELD CROP IMPROVEMENT ASSOCIATION

Howard B. Sprague, Secretary, New Brunswick, New Jersey

WHEAT
(*a*) Winter
Leap's Prolific
Dawson Golden Chaff
Poole

OATS
Kanota
Keystone

BARLEY
Velvet

RYE
Raritan
New Jersey Common

SOYBEANS
Hardinsoy
Wilson-5

CORN
Lancaster Surecrop (Jersey Strain)
Mercer White Cap
Reid Yellow Dent (Croshaw Strain)
Somerset Leaming
Hulsart Yellow Dent
New Jersey Hybrid 2

TABLE 51—*Continued*

NEW MEXICO CROP IMPROVEMENT ASSOCIATION

Wallace Johnson, Secretary, State College, New Mexico

WHEAT
- (a) Winter
  - Turkey
  - Kanred
- (b) Spring
  - Marquis
  - Sonora

CORN
- Reid Yellow Dent
- Mexican June
- Minnesota 13
- Mosby Prolific
- Ishacoo White
- Colorado 13

BARLEY
- Trebi

POTATOES
- (a) Irish
  - Brown Beauty
  - Bliss Triumph
  - Peach Blow
  - Irish Cobbler
  - Cathadin
- (b) Sweet
  - Maryland Sweets

COTTON
- College Acala
- Pardue Acala

ALFALFA
- Hardy Cimarron
- Black River

ONIONS
- Sweet Valencia

SORGHUM
- (a) Grain
  - Dwarf Hegari
  - Beaver
  - Dwarf Milo
  - Dawn Kafir
- (b) Sorgos (Sweet)
  - Sumac
  - Japanese Honeydrip
  - Redtop
- (c) Sudan grass
- (d) Broomcorn
  - Scarborough 7
  - Scarborough Dwarf
  - Acme Dwarf
  - Black Spanish

NEW YORK SEED IMPROVEMENT COOPERATIVE ASSOCIATION, INC.

Bruce P. Jones, President, Hall, New York

WHEAT
- (a) Winter
  - Honor
  - Junior 6
  - Forward
  - Yorkwin

OATS
- Cornellian
- Ithacan
- Upright
- Lenroc

RYE
- Rosen
- Cornell Sel. 76

BARLEY
- Alpha.
- Wisconsin 38
- Featherstone 7

SOYBEANS
- Cayuga

ONIONS
- Yellow Globe

TOMATOES
- Bonny Best
- Break O'Day
- Earliana
- John Baer
- Marglobe
- Nystate
- Pritchard
- Rutgers
- Stone

CORN
- (a) Field
  - Cornell 11
  - West Branch
  - Sweepstakes
  - Hybrid 29-3
- (b) Sweet Corn
  - Golden Cross Bantam

FIELD BEANS
- Robust Pea
- Perry Marrow
- Yellow Eye
- Bountiful
- Castile Marrow

POTATOES
- (a) Irish
  - Green Mountain
  - Irish Cobbler
  - Smooth Rural
  - Russet Rural
  - Bliss Triumph
  - Chippewa
  - Early Ohio
  - Golden
  - Katahdin
  - Spaulding Rose
  - Warba

GRASSES AND CLOVERS
- Kent Wild White Clover
- New York Wild White Clover
- Aberstwyth S. 50 Pasture Timothy
- Cornell 1777 Hay Timothy
- Svalof Victoria Perennial Ryegrass

NORTH CAROLINA CROP IMPROVEMENT ASSOCIATION

G. K. Middleton, Secretary, Raleigh, North Carolina

COTTON
- Improved strains of the following varieties:

WHEAT
- (a) Winter
  - Fulcaster

TABLE 51—*Continued*

NORTH CAROLINA CROP IMPROVEMENT ASSOCIATION—*Continued*

COTTON
- Mexican—1 in.–1$\frac{1}{16}$ in.
- Cleveland—1 in.–1$\frac{1}{16}$ in.
- Farm Relief—1 in.–1$\frac{1}{16}$ in.
- Carolina Foster—1$\frac{1}{16}$ in.–1$\frac{1}{8}$ in.
- Clevewilt—1$\frac{1}{32}$ in.–1$\frac{1}{16}$ in.
- Dixie Triumph (Wilt-Resistant)—1 in.–1$\frac{1}{32}$ in.

TOBACCO
- Cash
- White Stem Orinoco
- Bonanza
- Jamaica
- Virginia Bright Leaf
- Root-rot Resistant (Burley)

CORN
- Latham Double
- Biggs
- Jarvis Golden Prolific
- Weekly Improved
- Southern Beauty
- Holcombe Prolific
- Bagley Highland Horsetooth
- Cock's Prolific
- Kiker Indian Chief (Yellow)

POTATOES
- (*a*) Irish
  - Irish Cobbler
  - Green Mountain
- (*b*) Sweet
  - Porto Rico
  - Nancy Hall
  - Big Stem Jersey

PEANUTS
- Virginia Bunch
- Jumbo Runner

VELVET BEANS
- Early Speckle

WHEAT
- Leap's Prolific
- Gleason
- (*b*) Spring
  - Redhart
  - Purplestraw

RYE
- Abruzzi

BARLEY
- Tennessee 6

OATS
- Fulghum
- Lee
- Norton

SOYBEANS
- Laredo (Hay)
- Otootan (Hay)
- Virginia (Hay and Seed)
- Mammoth Yellow (Hay and Seed)
- Herman (Seed, Hay, and Early Pasture)
- Tokyo (Seed)
- Biloxi (Late Pasture)

COWPEAS
- Groit (Semi-Wilt-Resistant)
- Brabham (Wilt-Resistant)
- Iron (Wilt-Resistant)
- Taylor (Nonresistant)
- Whippoorwill (Nonresistant)
- New Era (Nonresistant)
- Clay (Nonresistant)
- Crowder (Nonresistant)
- Blackeye (Nonresistant)

LESPEDEZA
- Korean
- Common
- Kobe
- Tennessee 76

NORTH DAKOTA CROP IMPROVEMENT ASSOCIATION

E. M. Gillig, Commissioner, Fargo, North Dakota

WHEAT
- (*a*) Spring
  - Ceres
  - Thatcher
  - Reward
  - Marquis
- (*b*) Durum
  - Mindum
  - Kubanka

BUCKWHEAT
- Japanese
- Silverhull

OATS
- Gopher
- Victory
- White Russian
- Rainbow
- Iogold
- Anthony

FLAX
- Buda
- Linota
- Bison
- New Golden

BEANS
- Great Northern
- Navy Bean (Robust)

FIELD PEAS
- Chang
- Austrian
- Canadian Beauty
- French June

SOYBEANS
- Minsoy
- Wisconsin Black

TABLE 51—*Continued*

NORTH DAKOTA CROP IMPROVEMENT ASSOCIATION—*Continued*

RYE
- Dakold
- NDR 9
- Prolific (Spring)

EMMER
- Yaroslav

BARLEY
- Manchuria
- Wisconsin 38
- Velvet
- Trebi
- Hannchen

GRASSES
- Brome
- Slender Wheat
- Crested Wheat

CORN
- Dakota White Flint
- Gehu
- Mercer
- Falconer
- Pioneer White Dent
- Minnesota 13
- Rustler White
- Northwestern Dent

ALFALFA
- Grimm (Northern Grown)

POTATOES
- (*a*) Irish
  - Bliss Triumph
  - Early Ohio
  - Irish Cobbler
  - Viking
  - Green Mountain
  - Warba
  - Chippewa

MILLET
- Kursk
- Siberian
- German

SWEET CLOVER
- White Blossom
- Grundy County
- Yellow Blossom

OHIO SEED IMPROVEMENT ASSOCIATION

D. F. Beard, Secretary, Columbus, Ohio

CORN
- (*a*) Field Open-Pollinated)
  - Eichelberger Clarage
  - Johnson Clarage
  - Leaming
  - Medina Pride
  - Reid Yellow Dent
  - Woodburn
- Field (Hybrids)
  - Ohio Hybrid K 23
  - Ohio Hybrid W 17
  - Ohio Hybrid W 63
  - Ohio Hybrid C 41
  - Ohio Hybrid C 58
  - Ohio Hybrid C 72

CORN—*Continued*
  - Ohio Hybrid L 31
  - Iowa Hybrid 931
  - Iowa Hybrid 939
  - Indiana Hybrid 614
  - Illinois Hybrid 172
- Foundation Lines and Single Crosses for hybrids to be certified in 1937
- (*b*) Sweet Corn
  - Golden Cross Bantam (P39 x P51)

WHEAT
- (*a*) Winter
  - Fulhio
  - Gladden
  - Trumbull

OATS
- Franklin
- Fulghum
- Gopher
- Miami
- Wayne

BARLEY
- Velvet

SOYBEANS
- Ohio Manchu 1
- Scioto

OKLAHOMA CROP IMPROVEMENT ASSOCIATION

J. W. Chaffin, Secretary, Stillwater, Oklahoma

SORGHUM
- (*a*) Grain
  - Reed Blackhull Kafir
  - Hydro Blackhull Kafir
  - Standard Blackhull Kafir
  - Dwarf Milo
  - Beaver
  - Wheatland
  - Sunrise Kafir
  - Darso
- (*b*) Sorgos (sweet)
  - Red Top or Sumac

WHEAT
- (*a*) Winter
  - Turkey
  - Blackhull
  - Currell
  - Harvest Queen
  - Fulcaster
  - Tenmarq
  - Cheyenne
  - Kawvale
  - Comanche

COTTON
- Acala
- Rowden 40
- Mebane
- Oklahoma Early Triumph

OATS
- Fulghum
- Nortex
- Appler
- Lee Winter

TABLE 51—*Continued*

OKLAHOMA CROP IMPROVEMENT ASSOCIATION—*Continued*

SORGHUM
- Atlas
- African Millet
- (*c*) Broomcorn
  - Scarborough Dwarf
  - Evergreen Dwarf
  - Black Spanish Standard

CORN
- Southwestern Yellow Dent
- Midland Yellow Dent
- Reid Yellow Dent
- Oklahoma Silvermine
- Franklin Long John
- Mexican June

RYE
- Abruzzi

BARLEY
- Michigan Winter

OREGON CROP IMPROVEMENT ASSOCIATION

E. R. Jackman, Secretary, Corvallis, Oregon

WHEAT
- (*a*) Winter
  - Kharkof
  - Oro
  - Rio
  - White Holland
  - White Winter
  - Zimmerman
  - Hybrid 128
- (*b*) Spring
  - Baart
  - Marquis
  - Federation
  - White Federation
  - Rex

BARLEY
- Hannchen
- Meloy
- O. A. C. 6
- Union Beardless
- Trebi

OATS
- Black Winter
- Eclipse
- Climax
- Gray Winter
- Markton
- Support
- Victory

POTATOES
- (*a*) Irish
  - American Wonder
  - Beauty of Hebron
  - British Queen
  - Burbank
  - Cobbler
  - Earliest of All
  - Early Rose
  - Garnet Chili
  - Katahdin
  - Netted Gem
  - White Rose

RYE
- Spring
- Winter

ALFALFA
- Grimm
- Ladak

CLOVER
- Ladino
- Tennessee Anthracnose (Resistant Red)
- Ohio Hardy Red
- Willamette Sweet
- Midland

GRASSES
- English Rye
- Highland Reed Canary
- Reed Canary
- Highland Bent
- Astoria Bent
- Seaside Bent
- Colonial Bent

RAPE
- Dwarf Essex

SOUTH DAKOTA CROP IMPROVEMENT ASSOCIATION

U. J. Norgaard, Secretary, Brookings, South Dakota

(Certification in Charge State Seed Commissioner)

WHEAT
- (*a*) Winter
  - Turkey
  - Kharkov
- (*b*) Spring
  - Ceres
  - Marquis
- (*c*) Durum
  - Mindum
  - Kubanka

BARLEY
- Odessa
- Velvet
- Wisconsin 38
- Glabron
- Trebi

ALFALFA
- Grimm
- Cossack
- Ladak
- Dakota 12

OATS
- Richland
- Iogold
- 60-Day
- Swedish Select
- Gopher
- Cole

FLAX
- Bison
- Linota
- Redwing

TABLE 51—*Continued*

TENNESSEE CROP IMPROVEMENT ASSOCIATION

N. I. Handcock, Secretary, Knoxville, Tennessee

WHEAT
(*a*) Winter
Fulcaster

BARLEY
U. T. 5 (Beardless)
U. T. 6 (Beardless)
Union (Bearded)

SOYBEANS
Tokio

CORN
Neal's Paymaster
Jarvis Golden Prolific
Thompson's Prolific
Jellicorse
Hybrids 3, 10, 13, 14
15, 16

OATS
Fulghum
Kanota

LESPEDEZA
76
Korean
Kobe
Sericea

RED CLOVER
Tennessee Resistant

TOBACCO
White Burley

TEXAS STATE PLANT BOARD

E. P. Humbert, Chairman, College Station, Texas

COTTON
Acala
Lone Star
Rowden
Mebane
Texas Mammoth
Boykin
Kasch
Lankart
Paris Big Doll
Russell

POTATOES
(*a*) Irish
Triumph
Irish Cobbler
McLure (Peach Blow)

SORGHUM
(*a*) Grain
Dwarf Yellow Milo
Double Dwarf Yellow Milo
Texas Blackhull Kafir
60-Day Milo
Wheatland
Hegari
Spur Feterita
(*b*) Sorgos (Sweet)
Sumac (Red Top) Cane
Dwarf Sumac (Red Top) Cane
(*c*) Sudan Grass
(*d*) Broomcorn
Texas Scarborough Dwarf

CORN
Honey June
Horton
Laguna
Yellow Tuxpan
Yellow Surcropper
Surcropper Sugar
Golden Thomas

OATS
Nortex
Frazier

WHEAT
(*a*) Winter
Tenmarq
Turkey
Comanche

ALFALFA
Southwestern Common

UTAH STATE SEED CERTIFICATION SERVICE

E. P. Rassmussen, Salt Lake City, Utah

WHEAT
(*a*) Winter
Turkey Red
Kanred
Relief
Erect
(*b*) Spring
Dicklow
Federation
Early Baart

BARLEY
Trebi
Velvon
Club (winter)

OATS
Swedish Select
Markton

CORN
Minnesota 13
Improved Leaming

ALFALFA
Grimm
Hardigan
Cossack
Ladak
Pioneer
A–136

POTATOES
(*a*) Irish
Early Ohio
Bliss Triumph
Irish Cobbler
Idaho Rural
New York Rural
Green Mountain
Russet Burbank
Blue Victor

ONIONS
Utah Valencia

VIRGINIA CROP IMPROVEMENT ASSOCIATION, INC.

S. F. Grubbs, Secretary, Blacksburg, Virginia

WHEAT
- (a) Winter
  - V. P. I. 131
  - Leap's Prolific
  - Forward
  - Leapland
- (b) Spring
  - Purplestraw
  - Redhart

RYE
- Abruzzi

BARLEY
- Virginia Hooded
- Tennessee Winter Bearded

OATS
- Lee Cold Proof
- Norton Cold Proof
- Coker 32-1

TOBACCO
- Yellow Pryor
- Jamaica Wrapper
- Bonanza
- White Stemmed Crinoco

SOYBEANS
- Virginia
- Pocahontas

CORN
- Mountain White Dent
- Boone Co. White
- Johnson Co. White
- Virginia White Dent
- Woodburn White Dent
- Golden Queen
- Government 182
- Woods Dixie
- Highland King
- Yellow Dent (Woods)
- Clarage
- Eureka
- Yellow Ensilage
- Reid Yellow Dent

POTATOES
- (a) Irish
  - Green Mountain
  - Rural New Yorker
  - Irish Cobbler
- (b) Sweet
  - Nancy Hall
  - Big Stem Jersey
  - Little Stem Jersey
  - Hayman
  - Priestley
  - Porto Rico
  - Spanish
  - Maryland Golden

LESPEDEZA
- Korean
- Sericea

RED CLOVER
- Virginia Adapted

COTTON
- Trice
- Coker Cleveland
- 5-Strain-5

WASHINGTON STATE SEED CERTIFICATION SERVICE

Charles D. Gaines, Secretary, Olympia, Washington

POTATOES
- (a) Irish
  - Netted Gem
  - Burbank
  - Gold Coin
  - Earliest of All
  - White Rose
  - Early Red Rose
  - Beauty of Hebron
  - Bliss Triumph
  - Irish Cobbler
  - Early Ohio

STRAWBERRY PLANTS
- Marshall
- Narcissa

BENT GRASS
- Seaside Creeping Bent
- Colonial Bent

SWEET CLOVER
- Alpha 1

RED CLOVER
- Midland
- Cumberland

OATS
- Victory
- Support

BARLEY
- Ben Beardless

WEST VIRGINIA ASSOCIATED CROP GROWERS

R. J. Friant, Secretary, Morgantown, West Virginia

WHEAT
- (a) Winter
  - Leap's Prolific
  - Fulhio
  - Canawa

OATS
- Gopher
- Beeghley Select White Russian

CORN
- Reid Yellow Dent
- Lancaster Co. Surecrop
- Woodburn White Dent

SOYBEANS
- Kingwa

TABLE 51—*Continued*

WISCONSIN AGRICULTURAL EXPERIMENT ASSOCIATION

E. D. Holden, Secy., Madison, Wisconsin

WHEAT
- (a) Winter
  - Ped. 2 Turkey Red
  - Ashkof
  - Minturki
- (b) Spring
  - Thatcher
  - Progress
  - Sturgeon

BARLEY
- Wisconsin Pedigree 38 Barbless
- Wisconsin Pedigree Oderbrucker
- Velvet
- Peatland

RYE
- Wisconsin Pedigree Strains

CORN
- Golden Glow
- Cold Resistant Golden Glow
- Silver King
- Murdock
- Clark Yellow Dent
- Minnesota 13
- Northern Yellow Dent 25
- Smut Nose Flint
- Northwestern Dent
- Early Yellow Dent 8

SOYBEANS
- Manchu Ped. 3
- Wisconsin Early Black
- Mandarin Wisconsin Pedigree

OATS
- Wisconsin Wonder Ped. 1
- Swedish Select Ped. 5
- State Pride Ped. 7
- Forward
- White Cross Ped. 19
- Spooner
- Gopher

WYOMING CROP IMPROVEMENT ASSOCIATION

G. W. Boyd, Secretary, Laramie, Wyoming

POTATOES
- (a) Irish
  - Bliss Triumph
  - Irish Cobbler
  - Netted Gem
  - Red McClure
  - Warba

ALFALFA
- Grimm
- Cossack
- Hardistan
- Ladak
- A–136

CANADIAN SEED GROWERS' ASSOCIATION

W. T. G. Wiener, Secretary, Ottawa, Ont., Canada

WHEAT
- (a) Winter Wheat
  - Dawson Golden Chaff
  - Kharkov 22 M. C.
  - O. A. C. 104
  - Sun
- (b) Spring Wheat
  - Bluestem
  - Ceres
  - Early Red Fife
  - Garnett
  - Huron
  - Marquis
  - Mindum
  - Pelissier
  - Red Bobs 222
  - Red Fife
  - Reliance
  - Reward
  - Thatcher
  - White Russian

OATS
- Abundance
- Alaska
- Banner
- Carier
- Gold Rain
- Gopher
- Legacy
- O. A. C. 3
- O. A. C. 72
- O. A. C. 144
- Victory

BARLEY
- (a) Spring barley
  - Canada Thorpe
  - Charlottetown 80
  - Colsess
  - Duckbill
  - Hannchen
  - Manchuria
  - Mensury
  - O. A. C. 21

SWEET CLOVER
- Alpha
- Arctic

GRASSES
- Brome (Parkland)
- Brome (Superior)
- Crested Wheat (Fairway)
- Western Rye (Mecca)

FIELD BEAN
- Burbank
- Norwegian Brown
- Robust

FIELD PEA
- Arthur
- Chancellor
- Early Blue
- Golden Vine
- Mackay
- O. A. C. 181

TABLE 51—*Continued*

CANADIAN SEED GROWERS' ASSOCIATION—*Continued*

RYE
- (*a*) Spring Rye
  - Prolific
- (*b*) Winter Rye
  - Dakold

FLAX
- Bison
- Crown
- Longstem
- Premost
- Redwing

BARLEY
- Regal
- Trebi

TIMOTHY
- Swallow

RED CLOVER
- Atlaswede
- Ottawa
- Dollard
- Manhardy

SOYBEAN
- A. K. (Harrow)
- Mandarin (Ottawa)
- Manitoba Brown
- O. A. C. 211

ALFALFA
- Grimm
- Ontario Variegated

FIELD CORN
- Northwestern Dent (Lethbridge)
- Minnesota 23 (Colquhoun)
- White Capped Yellow Dent (Newman)
- Silver King (Wis. 7)
- Minnesota 13 (Worthy)
- Golden Glow
- Quebec No. 28 (M. C.)
- Quebec No. 28 (D. R. E. S.)
- Gehu (Maple Creek)
- Yellow Flint (Manalta)
- Longfellow
- Dakota White Flint (Maple Creek)
- White Flint (Saskatchewan)
- Salzers

TOBACCO
- Comstock Spanish Pomeroy
- Connecticut Broadleaf (Williams)
- Connecticut Havana 38
- Resistant Havana
- Belge 3007
- Grand Rouge 4
- Little Dutch (Ragondorf)
- Obourg Vincent
- Parfum d'Italie
- Canella
- Petit Havane
- Rose Canelle

In addition to these, the Association accepts for registration root crops and 120 varieties of Garden Crops.

TABLE 52 *

AVERAGE PURITY AND GERMINATION TESTS OF BEST COMMERCIAL GRADE OF SEED AND COMMONLY ACCEPTED WEIGHT PER BUSHEL

Kind of Seed	Purity	Germination	Weight per Bushel
	(Per cent)	(Per cent)	(Pounds)
Red clover	99.4	92.4	60
Alsike clover	98.3	91.5	60
White clover	96.9	90.8	60
Crimson clover	98.2	91.2	60
Sweet clover (hulled)	98.9	89.6	60
Bur clover (unhulled)			10
Lespedeza	93.9	82.1	25
Alfalfa	99.5	91.4	60
Timothy	99.6	93.5	45
Redtop †	93.2	90.5	14
Orchard grass	86.9	86.6	14
Kentucky bluegrass ‡	83.0	78.3	14
Bermuda grass	91.5	77.9	35
Brome grass (*Bromus inermus*)	87.7	91.8	14
Meadow fescue	97.8	91.2	22–24
Italian ryegrass	97.9	83.5	24
Perennial ryegrass	97.9	83.6	24
Hairy vetch	98.7	89.0	60
Spring vetch	98.7	92.3	60
Golden millet	98.8	92.9	50
Common millet	98.0	93.5	50
Siberian millet	97.9	92.7	50
Hungarian millet	97.5	92.4	48–50
Japanese millet	96.4	88.9	32–35
Broomcorn millet	99.3	92.1	50
Amber sorgo	97.9	88.2	50
Orange sorgo	97.9	88.5	50
Sumac sorgo	98.3	90.5	50
Sudan grass	98.0	91.1	32
Kafir	98.1	91.3	56
Milo	97.7	91.2	56
Feterita	97.9	91.1	56
Rape	99.2	91.8	50
Wheat	98.8	94.4	60
Corn (field) §	99.3	94.0	56
Barley	98.2	93.5	48
Oats	98.6	95.0	32
Rye	97.8	91.8	56
Flax	98.5	87.3	56
Buckwheat	98.6	92.7	48–52
Cotton	98.0	85.0	30–32
Cowpeas	96.1	91.4	60
Canada field peas	99.3	94.8	60
Soybeans	98.7	93.8	60

* From "Extension Service Handbook," United States Department of Agriculture.
† Fancy recleaned, solid redtop seed weighs 30 to 38 or more pounds per measured bushel.
‡ Fancy recleaned Kentucky bluegrass seed weighs 19 to 28 or more pounds per measured bushel.
§ Shelled.

MEASURING GRAIN, HAY, AND SILAGE

Grain. A bushel contains approximately $1\frac{1}{4}$ cubic feet. To find the capacity of a bin, find the number of cubic feet and multiply by $\frac{4}{5}$, or multiply by 8 and divide by 10.

Example: Bin $5 \times 5 \times 2$ feet $= 50$ cubic feet

$50 \times 8 = 400 \div 10 = 40$ bushels

Ear Corn. Two bushels of ears, by measure, are ordinarily required to make 1 bushel of grain. The cubic feet of ears, multiplied by 4 and divided by 10, give the bushels of grain. By weight, 70 pounds of ear corn usually equal 56 pounds (1 bushel) of shelled corn.

Hay. Some kinds of hay are heavier than others. The deeper the mow or the stack and the longer the hay has stood, the heavier it is per cubic feet. The bottom of a mow is much heavier than the top. Timothy hay is heavier than clover or alfalfa. About 500 cubic feet of well-settled timothy hay in a mow of average depth usually will weigh about 1 ton. In the bottom of the mow 450 cubic feet may weigh a ton. In low mows or stacks or in the top of a mow, more than 500 cubic feet of hay will be required to make a ton.

Straw. About 1200 cubic feet of well-settled straw will weigh 1 ton.

Silage in Round Silos. The original amount of silage put in the silo can be estimated from the Table 53. The depth to use is that found two days after filling stopped.

What is left in a silo after part has been used can be estimated as follows:

First. Find the original amount of silage put in the silo by referring to the table.

Second. Find the amount of silage that has been used, by the same method, using as depth the difference between the present depth and the depth 2 days after filling.

Third. Subtract the amount used from the original amount. The difference is the approximate amount of silage remaining in the silo.

TABLE 53

SILAGE TABLE—APPROXIMATE CAPACITIES OF CYLINDRICAL SILOS IN TONS

Depth of Silage Two Days After Filling	Inside Diameter of Silo in Feet					
	10	12	14	16	18	20
(Feet)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)
1	1	1	1	2	2	3
2	2	2	3	4	5	6
3	2	3	5	6	8	9
4	3	5	7	9	11	13
5	4	6	9	11	14	17
6	5	8	11	14	17	21
7	7	9	13	17	21	25
8	8	11	15	20	25	31
9	9	13	18	23	29	36
10	10	15	20	26	33	41
11	12	17	23	30	38	46
12	13	19	25	33	42	52
13	14	21	28	37	47	58
14	16	23	31	41	52	64
15	18	25	34	45	57	70
16	19	28	38	49	62	77
17	21	30	41	53	67	83
18	23	32	44	58	73	90
19	24	35	48	62	79	97
20	26	38	51	67	85	105
21	28	40	55	72	91	112
22	30	43	59	77	97	120
23	32	46	63	82	103	128
24	34	49	66	87	110	135
25	36	52	70	92	116	143
26	38	55	74	97	123	152
27	40	58	79	103	130	160
28	42	61	83	108	137	169
29	44	64	87	114	144	178
30	47	67	91	119	151	187
31	49	70	96	125	158	195
32	51	74	100	131	166	205
33	53	77	105	138	173	214
34	56	80	109	143	181	224
35	58	84	114	149	188	232
36	61	87	118	155	196	242
37	63	90	123	161	204	252
38	66	94	128	167	212	262
39	68	97	133	174	221	272
40	70	101	138	180	229	280

TABLE 54

POUNDS OF NITROGEN IN ONE TON HAY AND IN THE ROOTS EQUIVALENT TO EACH TON OF HAY; ALSO THE ESTIMATED AMOUNT TAKEN FROM THE AIR *

	Pounds in Hay	Pounds in Roots	Total	Pounds Taken from the Air †
Red clover	54.0	23.55	77.55	51.70
Alfalfa	51.2	20.47	71.67	47.78
Sweet clover	48.2	14.70	62.90	41.93
Crimson clover	57.0	14.77	71.77	47.85
Vetch	66.8	9.04	75.84	53.56
Cowpeas	54.0	4.90	58.90	39.27
Velvet beans	46.8	3.86	50.66	33.77
Soybeans	51.6	5.30	56.90	37.93
Blue lupines	52.0	4.79	56.79	37.86
Yellow lupines	51.4	5.53	56.93	37.95
Field peas	56.0	2.27	58.27	38.85

* Adrian J. Pieters, *Green Manuring*, John Wiley & Sons, 1927.
† Two-thirds of total.

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